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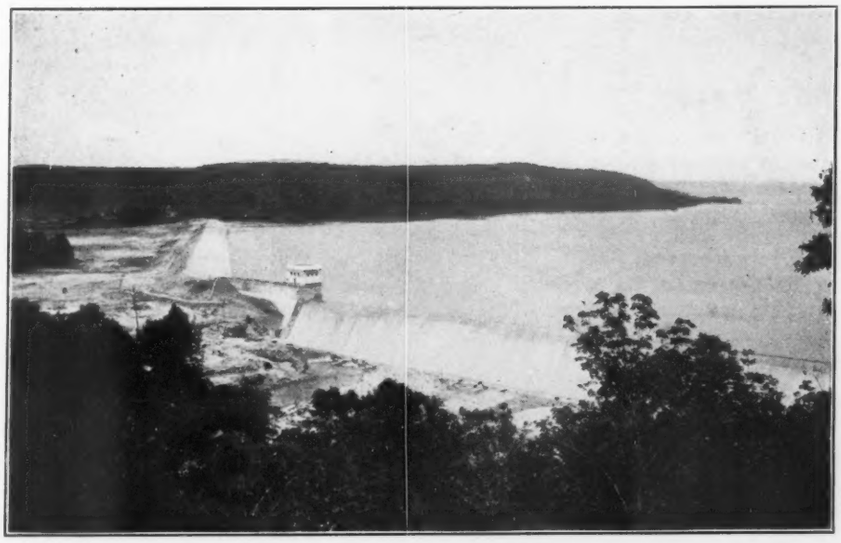

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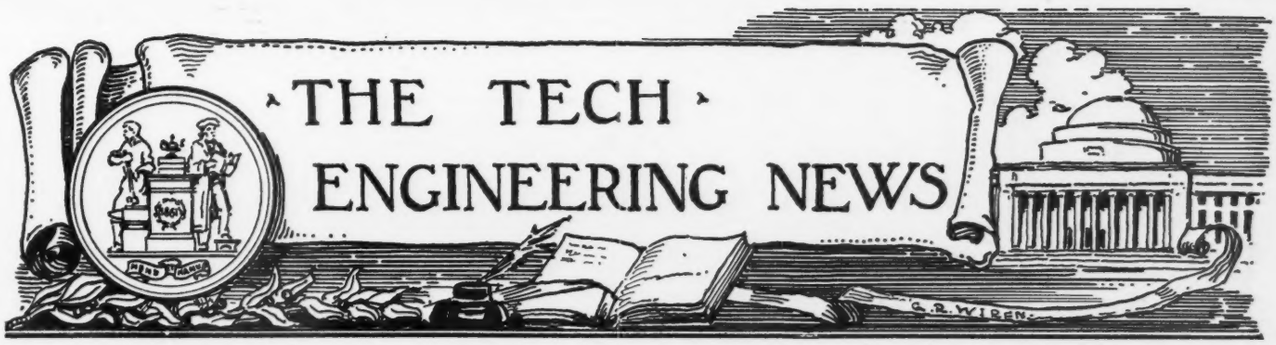

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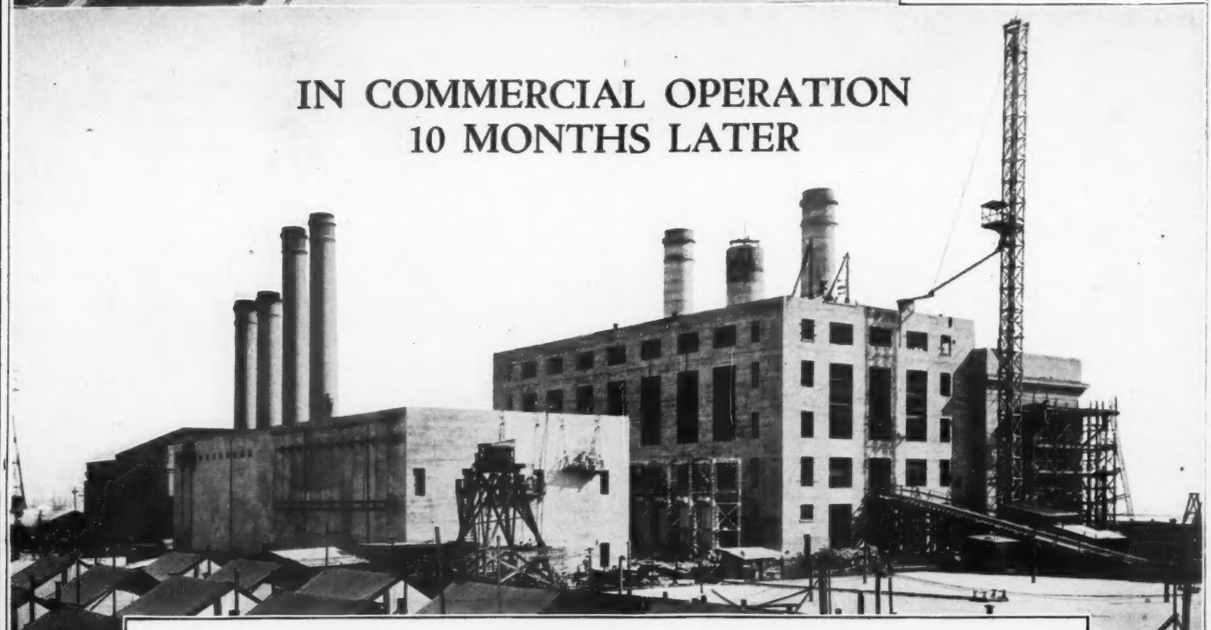

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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME V | FEBRUARY, 1925 | NUMBER 7

The Solar Eclipse

The much-heralded spectacle as seen at Westerly

By GEORGE L. HOSMER, '97

Associate Professor, Department of Civil Engineering, Massachusetts Institute of Technology

THE writer of this article was booked six months ago to take part in an astronomical expedition to Nantucket Island to observe the eclipse of January 24. Within a month the plans of that party were completely changed, so there seemed to be nothing alse to do but to go down to Westerly, R. I., and see the eclipse, without further responsibility than to consult timetables and purchase tickets. For one who has "observed" several eclipses but never had a good look at one this was a luxury.

Those who left Boston Saturday morning on the special trains for Westerly saw a perfectly clear sky and, as the air was still and cold, had no doubt that it would be a fine morning for viewing the eclipse. But before sunrise little fleecy clouds appeared along the eastern horizon and encouraged speculation as to what would happen during the next two hours. The planets Jupiter, Mercury and Venus, which were to become visible during the eclipse, could be plainly seen before sunrise. The clouds became thicker and thicker until at about 8:40 when trains were arriving at Westerly the sun was well covered. This cloud bank was heavy to the south and southwest and was moving from that direction, so it began to look as though the pessimists would have it all their own way. The clouds moved rapidly enough, however, to clear away this bank and a few minutes before totality there was no doubt that the sky near the sun would be clear, although there were clouds in the northwest.

An attempt to observe the approach of the moon's shadow was unsuccessful. The positions near the railroad station were not sufficiently high to give a good view of distant hills. But the chief difficulty seemed to be caused by the white covering of snow and also, perhaps, reflections from the white clouds. Instead of the shadow coming across the landscape with startling swiftness and looking like a black thundercloud the light seemed merely to tone down a little and the eclipse was on before one realized it.

The equatorial streamers of the corona were long and distinct, those on the western edge being the more pronounced. That on the northwestern edge, which would be nearly at the vertex (top) as seen from this point, was perhaps the longest, and instead of a single line forming a clean edge, appeared to consist of several lines crossing each other. The streamer on the northeast edge was shorter and less pronounced than those on the west edge, and that on the southeast was indefinite. The polar streamers were not so marked as they are sometimes. The general appearance of the corona was much like that seen in the southeastern states during the eclipse of May 28, 1900, but more brilliant.

During totality the three planets mentioned were plainly visible about 30° to the right of the sun, and Altair and Vega above and to the left. Along the southern horizon was a bright streak of light, probably reflection from clouds of the light coming from outside the eclipse belt. Just before the third contact brilliant red spots were seen close to the western edge of the moon. These reached out for a long distance and blended together in places, the color changing more to an orange. This took place very rapidly and soon was confused with the first streak of light from the photosphere, so it will require a study of the photographic plates to learn just what did occur. Those provided with field glasses could see a red ring close to and entirely surrounding the moon.

The shadow bands were watched about the time of third contact by two observers, who described them as follows: The bands seemed to be of two distinct classes; the first were small, distinct, dark bands about an inch wide and with a pitch—notice that the observers were mechanical engineers—of five inches. These moved with a velocity of perhaps five feet per second, although this may really have been higher, and their long dimension was directed toward the sun and their motion was across the track; afterwards these bands turned several degrees to the right, that is, pointing more southerly. The second bands were wider, perhaps five or six inches, not so dark and definite, and much more difficult to observe. They moved across the track and at a much higher velocity, estimated at 100 feet per second. The small bands were seen by looking vertically downward onto the snow from a height of about 10 feet. The larger, fainter ones were seen only at some distance away. These lasted for about 15 seconds and were seen to persist for some time after third contact.

The weather conditions at the time of the eclipse were perfect. The heavy clouds that covered the sky during the middle of the day reminded the thousands of observers how fortunate they had been during the morning. The New Haven railroad handled the many trains with little delay and so that all parties arrived in Westerly in plenty of time to find good positions from which to see the eclipse. The Westerly Board of Trade did much to make the excursion a success, by providing general information and even free transportation to hills from which the best view could be had. The traffic grew to such proportions in the last few days that merely to get the crowd into Westerly and back again without a hitch was no small accomplishment. On account of the density of population within and near the eclipse track the total number of observers was very great. It is probably safe to say that there was never before an eclipse so systematically observed by so many people.

Spavinaw Water Supply Project

How a western city provided for its present demand and future growth

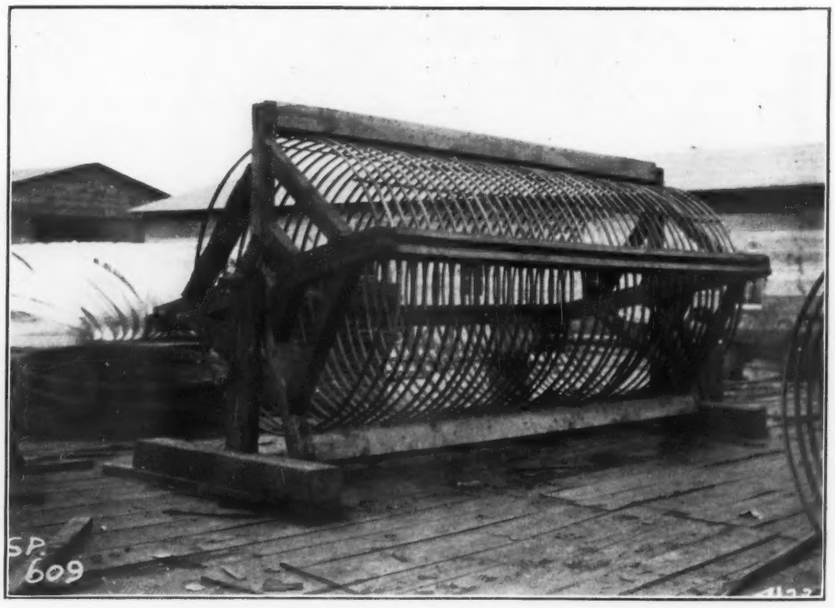
By W. R. HOLWAY, '15
Chief Engineer, City of Tulsa, Oklahoma

THE City of Tulsa, Oklahoma, has just completed a big water project, connecting the city with her new source of supply, the Spavinaw Creek in the foothills of the Ozarks, sixty miles to the northeast. Across this creek the city has built a dam 55 feet high, with solid masonry spillway 800 feet long, concrete non-overflow section 150 feet long, and earthen embankment with concrete core-wall 2,600 feet in length. This structure impounds approximately twenty billion gallons of water, clear and soft, unlimited in quantity, and of a quality amply satisfactory for every use, industrial or domestic. The dam creates a beautiful lake, six miles long and covering 1,800 acres. It lies between rugged, wooded hills, where the soil and the location are peculiarly fitted for a reservoir site. A limestone ledge furnishes perfect foundation conditions, and from gravel beds down the river came much of the material for the concrete aggregate. A washing and screening plant prepared this material for use, and about 70 per cent of the sand and all of the stone was secured in this way. The remainder was shipped in over the Spavinaw Railroad. The concrete was mixed, handled, and poured by an Insley tower and chuting system, augmented by a movable tower and an auxiliary plant on the other bank of the stream. Most of the plums were secured from the site of the dam and deposited by a Clyde derrick and a cableway. The construction of the dam occupied 16 months and the cost was approximately $845,000. The contractor was the Standard Paving Company of Tulsa.

This company also built the Tiawah Tunnel, which lies midway of the 55-mile conduit, and which was necessary to maintain the gravity flow throughout the line. Here the cost of tunneling the ridge was balanced against the cost of a longer pipeline at lower levels, and the tunnel found cheaper. However, here the city planned for the future, for the tunnel, nearly two miles long with its approaches, is seven feet in diameter, and thus will carry three times as much water as the rest of the conduit. Tulsa may have to build additional pipelines at some future time, but probably not another tunnel. This tunnel was excavated from four headings, through dense shale, and was lined with six-inch concrete to make the interior smooth and tight. This lining was placed by a pneumatic concrete mixer and was shot into the movable forms under 100 pounds pressure. The approaches to the tunnel were of monolithic concrete construction, 84 inches in diameter, and built in deep open cuts. The total cost was $370,000.

Mohawk Reservoir, five miles from Tulsa, was an interesting earthwork job. The engineers, in making their surveys in search of the gravity line, saw that Bird Creek bottoms north of the city near Mohawk are lower than the banks of the Arkansas River, on which Tulsa is built. The difference in elevation between these bottoms and Spavinaw Dam is approximately 90 feet. This difference in head made it possible to bring the water the 55 miles to Mohawk by the force of its own gravity alone. Here was constructed a storage reservoir and a pump station to lift the water to the city. A little stream in the bottoms was diverted by a small dam and levee, and in the old bed of this stream elevating grader outfits stripped the soil and earth and built a circular embankment, a mile and a half long and 18 feet high. This embankment, after standing some months for settlement, was paved on the inside with 4-inch concrete to protect the bank from wave action. The cost of the earthwork construction was $122,000 and of the paving was $50,000. This reservoir has a capacity of 500,000,000 gallons, and serves merely as an emergency supply in case of pipeline breaks, or a short period of cloudy water due to floods at Spavinaw. The pumps take the water directly from the conduit, and the surplus only flows into Mohawk Reservoir. At present this surplus is more than two-thirds the amount the conduit supplies, for this whole system was built with an eye to the rapid future growth of the city.

The pump station, built on the banks of this reservoir, is a thoroughly modern plant. Here, as at the dam, great care was taken in the design and construction from an architectural standpoint, since these two structures are the only ones on the entire project which show above the ground. The station was built by the E. J. Merkle Contracting Company of Kansas City at a cost of $372,000. The water flows through screens into a receiving well, where it is chlorinated, and then to the aerator of concrete step design. In the pumping station are two 12,000,000 gallon De Laval turbine-driven pumps which lift the water through four miles of 30-inch steel force main to the high service reservoir on a hill just north of the city. These pumps operate against a 350-foot head. Two 300-H. P. water tube boilers furnish the steam. These boilers are equipped to use either gas, oil, or coal. For reserve pumping equipment it is planned to install at this station the 12,000,000 gallon Allis-Chalmers cross compound crank

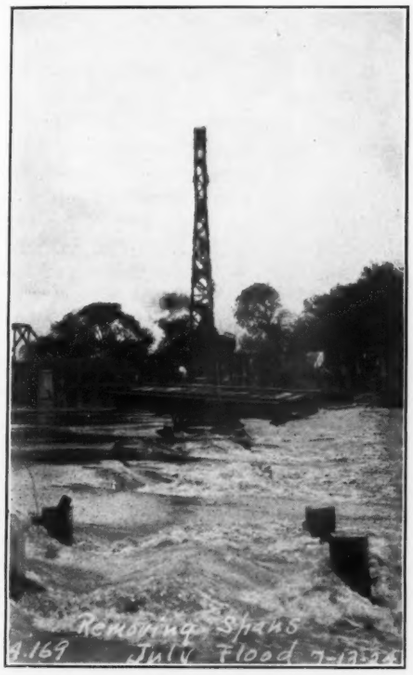


SETTING UP OUTSIDE RE-ENFORCING CAGE

The cage is of welded steel bars and is a step in the construction of re-enforced concrete pipe.

and flywheel pumping engine, which has been in use at the old plant only about four years.

The high service reservoir, into which the water is pumped, is constructed of reinforced concrete and gunite, is circular in shape, and is built almost entirely in sandstone



CRANE REMOVING BRIDGE SPANS ON APPROACH OF FLOOD

The Oklahoma rivers with their high banks presented troublesome problems.

excavation and covered with a concrete flat slab supported on concrete columns. The capacity is 10,000,000 gallons. From here the water flows directly into the mains. The Traylor-Dewey Company of Allentown, Pa., built this reservoir at a cost of $160,000.

To carry the water into the city, approximately 10,000 feet of 30- and 39-inch cast iron mains were laid as a part of this project.

The major work was the construction of the big gravity conduit from Spavinaw Lake to Mohawk Reservoir. The cost of this part of the work was over $4,000,000, or more than half the cost of the whole work. Under this contract 28 miles of 60-inch and 25 miles of 54-inch pipe were laid, the difference in size being due to the fact that the steeper gradient west of the tunnel allowed smaller pipe to be used. The drop for the 60-inch is about one foot to the mile; for the 54-inch it is approximately 1.8 feet per mile. Because of the fact that the difference in elevation between the surface of Spavinaw Lake and the surface of Mohawk Reservoir is only 75 feet, a pipe had to be chosen in which the friction losses would be very small, and the questions of cost and of permanency also had to be considered. The pipe chosen was precast, reinforced, concrete pipe. In connection with the manufacture and laying of this pipe, a standard gauge railroad had to be built for the transportation of the pipe, there were various difficult excavation problems to be solved, five railroads and ten good-sized streams to be crossed. In October, 1922, this contract was let to the Walbridge-Aldinger Company of Detroit, with the Lock Joint Pipe Company of New York sub-letting the manufacture and laying of the pipe. It was decided, because of accessibility to supplies, to make all of the pipe at Verdigris, Oklahoma, a tank town on the Frisco Railroad, twenty miles east of Tulsa. Here a 40-acre tract of land was leased. In 17 months the Lock Joint Pipe Company erected their mammoth plant and manufactured 53 miles of pipe, a splendid accomplishment. The work of excavating and backfilling the trench, of constructing the railroad and transporting the pipe did not move along so smoothly. Very bad and unusual weather conditions were encountered. The Oklahoma rivers with their high banks are treacherous in flood times, and many a bridge was washed away and lengths of track disappeared in the mud. Differences of opinion concerning classification and methods of work developed, and in January, 1924, the contractors abandoned their contract. The pipe manufacturers agreed to contract with the city and the Water Commission took the work over almost immediately and carried it on to a successful finish under the direct supervision of their engineer, W. R. Holway of Tulsa. The work was pushed night and day along the whole line and when, in October, almost two years to a day since the first contracts were let, the last pipe was lowered into position, the City of Tulsa congratulated herself on performing a good job of construction. When the line was tested for leakage, it was found that the conduit, designed to deliver 25,000,000 gallons a day, was delivering almost 3,000,000 gallons more than the expected amount. The pipe company has received, according to contract, a substantial bonus, for the total leakage was found to be only about 83 inch-gallons for the whole line, and the bid price was based upon 165 inch-gallons for the 60- and 150 inch-gallons for the 54-inch pipe.

The pipe was manufactured in 12-foot lengths, in a plant whose capacity was 96 such lengths a day. This plant consisted of four independent units, interconnected with switching tracks. Each unit consisted of cement storage sheds under which were the mixers; of the gantry track and the double gantry crane which poured the concrete and handled the forms, reinforcing, and the finished pipe; the bases on which the pipe was poured; and the racks on which it was cured. Each length was reinforced for a certain head and so had to be distributed to a certain point in the line. The reinforcement consisted of an inner cage of triangular mesh and the outer of mesh or welded steel bars, according to the internal pressures. The pipe was poured between steel forms, very carefully designed and handled so that a remarkably smooth pipe resulted. The joint is known as the lead-steel joint, formed by a lead, fibre-filled gasket caulked between the galvanized steel bell-and-spigot rings. After the pipe was poured, it was covered by canvas jackets and allowed to stand under moist steam for three days, which hastened the process of curing. It was then placed on the racks, where it remained until ready to be loaded onto the cars of the Spavinaw Railroad and to be hauled to its position in the line. Each pipe length weighed approximately seven tons, and it is one of the records of the job that a length was never dropped.

The pipe was distributed along the right of way as fast as the railroad could handle it, but the trench was

(*Continued on page 266*)

LAYING PIPE IN GRAND RIVER COFFERDAM

A trench was excavated in the rock and the entire line encased in a concrete jacket.

A Mercury Heating System

A new development which will prove invaluable in heat transfer at constant temperature

By JOSEPH MOOSEBRUGGER, '21
National Aniline Co., Buffalo, N. Y.

AMONG the less commonly known but very effective and efficient means of heat transfer is the use of mercury vapor. Very little information on this interesting subject is available for the uninitiated investigator. However, although it is not generally available, some information has been gathered by a few pioneers in the field and results have been attained. Whatever is known has been obtained only after years of experimenting, many failures and few successes. The information gathered is jealously guarded by the investigators as a secret of great commercial value. Two large concerns are investing heavily in the future of mercury vapor. As each is pursuing its investigations along different channels to attain distinctly different goals, they are not conflicting with one another. One is pursuing the practicability of the use of mercury vapor along mechanical lines, the other chemical. To be more explicit, the one is developing the use of mercury vapor for power production, the other is using it for temperature control in chemical reactions. It will be realized at once that mercury vapor is extremely interesting in applications to either case, that it must have certain features that stamp it as being more desirable than other mediums of heat transfer.

No great gain in economy can be expected in the development of power by mercury over the now almost universally used methods of power development—steam and water. Water power is the least expensive at the present time and steam follows as the next.

However, steam power development has been so standardized and improved during the last quarter century that radical improvements are hardly to be expected in the future, and the plan of a mercury vapor power plant would be along the lines of present steam plants. High installation and maintenance costs of the mercury system preclude the possibility of a saving over present steam plant designs. Attention is therefore directed toward mercury vapor heating systems applied to chemical reactions or temperature control before, during or after reactions, by which excellent results have been obtained. At low pressures of only an inch of mercury or several inches, as appears most desirable, temperatures can be maintained in jacketed vessels far more satisfactorily than could be expected from direct firing or steam. Mercury, of course, has limitations inasmuch as it vaporizes at 357° C. This, being higher than ordinary steam temperatures, makes mercury vapor desirable at temperatures not reached by steam at less than very high pressure. Oil heating is also unreliable on account of the lack of uniformity and high pressures required.

The vaporizing temperature of mercury can be lowered by operating a mercury system under vacuum. The actual operating pressure and temperature is determined by the character of the reaction or the heat required in the vessel to which mercury vapor is to be applied.

A simple form of mercury heating system is that shown in figure (1). The system shown is complete as an elementary layout. "A" is the mercury vapor generator or more commonly known as the boiler, the general construction of which is shown in figure (2). Vapors leaving "A" pass into the pipe line, through valve "C" into the jacket of the vessel "D." Condensate forming in the jacket returns through pipe line at the bottom of the vessel "D." "B" is a bubbler, vapors entering through a line tapped into the header. Vapors passing through enter the condenser "F," where they are condensed and fall into the return line to the boiler.

The boiler consists essentially of an outer shell "A," which is simply a piece of half-inch boiler plate bent to a circular form of the desired boiler diameter and butt welded at the joint. The ends of the cylinder thus formed are fitted with flat plates also welded in place. The inner shell "B" also consists of half-inch boiler plate bent to a circular form and of such diameter as to allow a gap of approximately a quarter to three-eighths of an inch between the inner and outer cylinders.

Like the outer shell the inner one also has a flat plate on the bottom. The upper plate "C" at the top of the inner shell is not located at the very top rim but at a point about six inches below the upper edge, forming a cup about six inches deep. The inner shell "B" is set into the outer cylinder in such manner as to allow a gap between "A" and "B" of about one-fourth inch, both on the sides and at the bottom. Three holes are drilled through the bottom of the outer shell to allow the passage through of three nipples previously welded into the inner shell. They are set at 120-degree intervals on the bottom. These are welded to the outer shell and serve to assist in holding the inner shell in position. A pipe "D" extends from the cup "C" in the inner shell through the bottom of both the inner and outer shells. This pipe is the return for the mercury condensate. Two funnel-

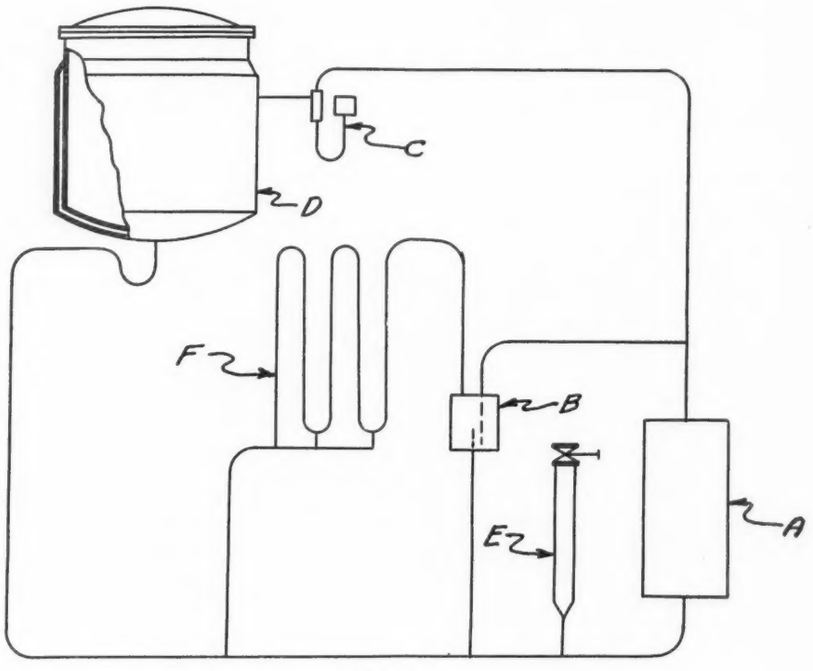


FIGURE 1

shaped plates are located at the top of the outer shell. These are baffle plates; the upper is fixed in position and has an outside diameter corresponding to the inside diameter of the outer shell. The hole at the lower end of the upper baffle is approximately one-half the outside diameter of the lower one. The lower baffle is smaller than the large one, but has the same pitch, thus making them parallel. It is not fixed in position but rests upon supports from either the outer shell or suspended from the upper baffle and is therefore

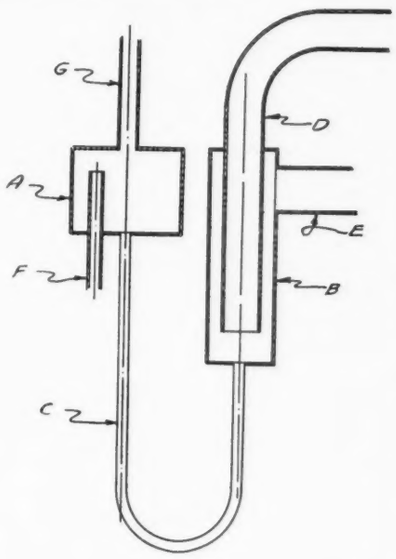


FIGURE 3

free to move. The hole in the lower end of this baffle is not more than an inch in diameter.

It is necessary in building up this boiler to make all joints welded. This is true on account of the fact that smooth surfaces are desired throughout and to eliminate any variation in the gap between the inner and outer shells. Any unevenness of surface is apt to prove a pocket in which liquid mercury may collect. For the same reason all piping must have welded joints as screwed joints would prove to be pockets for liquid mercury.

In operation, mercury would fill the narrow gap between the inner and outer shells. The vapors rising in the boiler would pass the baffle and leave through the header at the top. In passing the baffles the path of the vapors would be as indicated by the arrows. In passing, any condensate carried up and any dropping back through the header would be dropped through the holes in the baffles into the cup in the inner shell. This cup is filled with liquid mercury at all times and is a reservoir supplying by overflow to the vaporizing gap. The pipe "D" is the return line through which all condensate is returned to the boiler. A standpipe in the vicinity of the boiler and connected to the return serves to indicate the level of the mercury in the generator.

This last, the height of the liquid mercury, must be watched very carefully on account of the fact that the amount of mercury that can be used in the system is limited and definite. The vaporizing chamber, which is the gap between the two cylinders, loses mercury as vaporization takes place and must be replenished by overflow from the cup. The standpipe serves to indicate the liquid level in the boiler. It also serves as the medium through which liquid mercury is supplied to the boiler.

All pipe lines used with mercury vapor should be welded as explained above; all should be new and smooth inside; all bends should have long sweeps; both lines and bends should be accurately laid out and should be definitely pitched either toward the boiler or preferably toward the return line. These precautions are necessary to prevent the loss of mercury by lodgment of condensate in fittings and to eliminate the possibility of pockets in the line.

The use of gate or globe valves even of the very finest type is undesirable in a mercury vapor installation on account of the fact that leakage is apt to take place. No stem valves have yet been found that are entirely satisfactory at less than great expense. On account of the low pressure used in the system being described a mercury seal valve has been found to give most satisfactory results. This type of valve is so constructed that liquid mercury is used to open the lines to the passage of the vapor or to close them against it. The general features of this type of valve are shown in figure (3). It consists of two chambers, "A" and "B" interconnected by a return bend section of small pipe, "C"; "D" is the header through which the mercury vapor is being distributed; if the chamber "B" is empty, the vapor will enter through "D" and leave at "E." When such is the case, the valve is said to be open, the liquid mercury is in the return bend and the chamber "A" up to the level of the standpipe. The mercury is drawn up into the chamber "A" by vacuum applied through the pipe "G" and supplied from a vacuum tank. The vacuum exerted on the valve is indicated by a manometer gauge on the line "G." When the vacuum is released the mercury settles to an equal level in the two chambers. The mercury rising in "B" will close the pipe "D" against the passage of vapors through the chamber "B." The two chambers are so located that the level of mercury in "B" effectively seals the chamber against the passage of the vapors. If the pressure in the line is three inches, a four-inch seal against "D" will be entirely satisfactory. The formation of condensate in "B" from the vapors passing through is taken care of by the standpipe "F." A constant vacuum maintained at "G" keeps a constant quantity of mercury in the valve, because an excess will be discharged from "A" through the standpipe, which leads into the condensate return line.

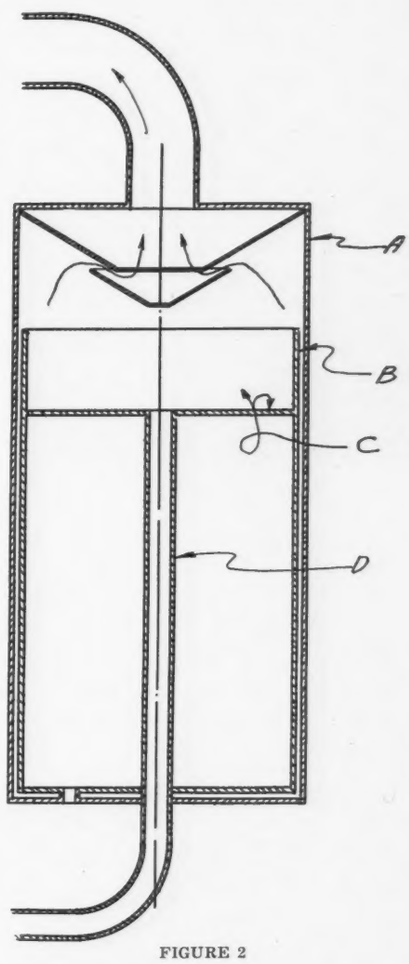


FIGURE 2

It will be seen that this valve does not allow of any exposure to the atmosphere and that there is no possibility of contact with the outside air and that no leakage of the dangerous fumes could occur except through a break in the line.

This type of valve is adaptable to low pressure installations. Valves of similar design have been installed on a line in such a manner that they could be used either to open or close by either vacuum or pressure, thus allowing the system to be operated under one or the other. The pressure under which it is operated is deter-

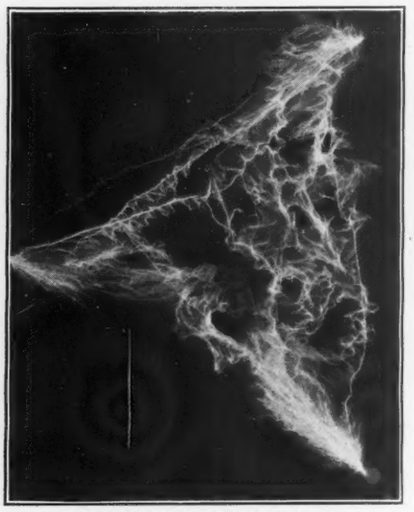
(*Continued on page 264*)

Lightning

A summary of the conclusions drawn from an investigation of both natural and artificial electric discharges

By F. W. Peek, Jr.
Pittsfield Works, General Electric Co.

A STUDY of lightning is of scientific importance because there is manifest in the flash the dynamic effect of the electrons and irons, he elemental bricks of which, it is believed, all matter is made; it is of engineering importance because an exact knowledge of the characteristics of lightning will make it possible to protect life, buildings, powder magazines, oil tanks and transmission lines against it. The ideal method of making such a study is by observations of natural lightning in the field and researches with artificial lightning in the laboratory. This article is a report on such a combined study.



1,000,000-VOLT 3-PHASE ARC
The Y-Delta is nine feet on a side.

The artificial lightning was obtained by means of the author's lightning generator which supplies 2,000,000 volts at an energy of 2,000 watt seconds. The power may be several million kilowatts or horse-power. The character of the discharge is similar to that of natural lightning. The destructive effects are also similar; fires may be set, metal conductors disappear, wood may be blown apart, discharges in water or oil produce explosive results, etc.

The experiments with natural lightning were made in the mountains of Colorado and elsewhere. The conclusions from this study are as follows:

The Voltage, Energy and Character of Lightning

A thunder cloud discharges to earth when the voltage along the discharge path is about 1,000,000 volts per foot. The effect of the thunder cloud is not local, but the atmosphere becomes electrified for a considerable distance. Thirty-two thousand volts for each foot above ground may occur at a quarter of a mile from the flash; 12,000 volts at a half mile and 3,000 volts at a mile.

When the flash occurs current flows from the cloud to ground and the potential of the cloud becomes zero in a few micro-seconds.* The cloud may become charged in the opposite direction at a lesser voltage a few micro-seconds later and so on. This is called an oscillatory discharge. Most discharges seem to be non-oscillatory or impulsive. The electrical energy is changed into heat, light, sound and chemical energy. The chemical changes take place in the path of the discharge. The oxygen molecule is split up and partly recombines as ozone. Nitrous oxides are also formed as well as nitric acid in the presence of moisture. Along the discharge path are untold numbers of electrons and ions moving at enormous velocities. It is a matter of speculation whether this intensive ionic bombardment of the oxygen and nitrogen atoms transmutes some of them into helium or hydrogen.

The voltage of lightning is of the order of 100,000,000. This is about one million times the voltage of the ordinary lighting circuit or one thousand times the voltage of very high voltage transmission line. The current may be 80,000 amperes and the energy 13,500 Kw-seconds or 3.8 Kw-hours. The energy is sufficient to operate an automobile about five miles or an electric toaster for a day. Since this energy is dissipated in a very short time the power may be several thousand million kilowatts or horse-power. The effect is thus explosive and destructive.

The voltage was arrived at by researches with artificial lightning on models of clouds, etc., built to scale. This voltage measurement was described in a lecture before the Institute last year and caused considerable interest. It has since been further confirmed. It may be of interest to

* Micro-second equals a millionth of a second.

TREE SHATTERED BY LIGHTNING
This illustrates physical destruction caused by direct stroke.

point out that the voltage of the lightning generator is about two per cent and the power about two hundredths per cent of natural lightning. This practically corresponds to the lightning energy that appears on transmission lines.

Voltage Disturbances on Transmission Lines

A lightning flash in the vicinity of a transmission line may cause dangerous voltage on the line. The line is very seldom directly struck but the effect is generally by induction. The line, as well as the atmosphere around it, becomes electrified by the cloud. The charge on the line is released when the cloud discharges to the ground. The voltage on the line reaches its maximum at about the time the cloud voltage reaches zero. The line voltage becomes equal to the voltage of the atmosphere above ground at that position in space just previously to the discharge but of opposite sign.

The maximum voltage induced on the line is one or two per cent of the cloud voltage. The energy is of the order of 1,350-watt seconds. The character of the discharge is generally impulsive and reaches its maximum in a few micro-seconds. In fact, it corresponds closely with the discharge from the lightning generator in voltage, energy and duration. The maximum possible voltage on any line can be found by multiplying the height of the line in feet by 100,000.

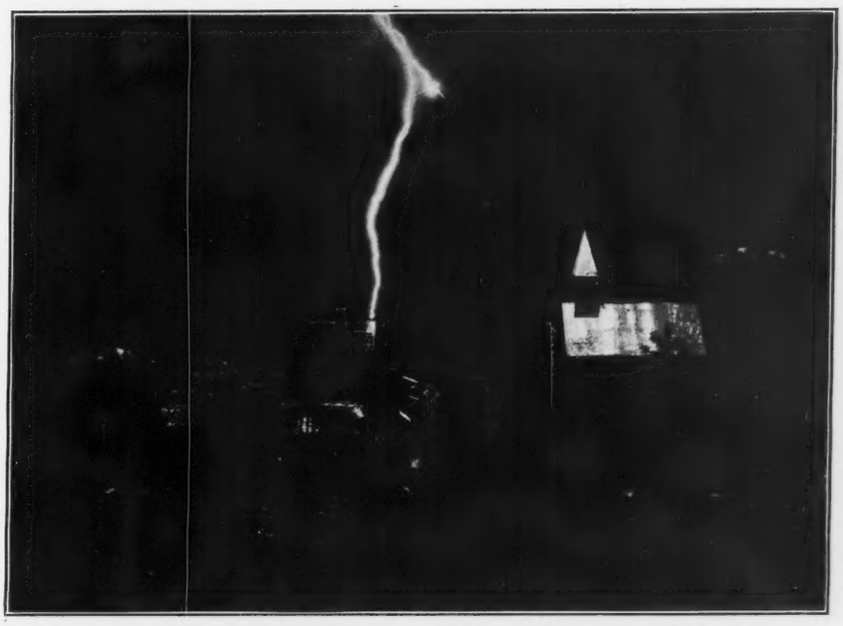
A lightning disturbance travels over the line at the velocity of light and is dissipated to a considerable extent by losses; it may double in value when it strikes the end of the line where it starts back. If the voltage is high enough it may break down insulators or discharge over an arrester. If no break occurs it is eventually dissipated by losses.

A grounded wire placed near the line conductors reduces lightning voltages on transmission lines to less than half. Several ground wires reduce the lightning voltage still more. The ground wire is also a good protector against direct strokes.

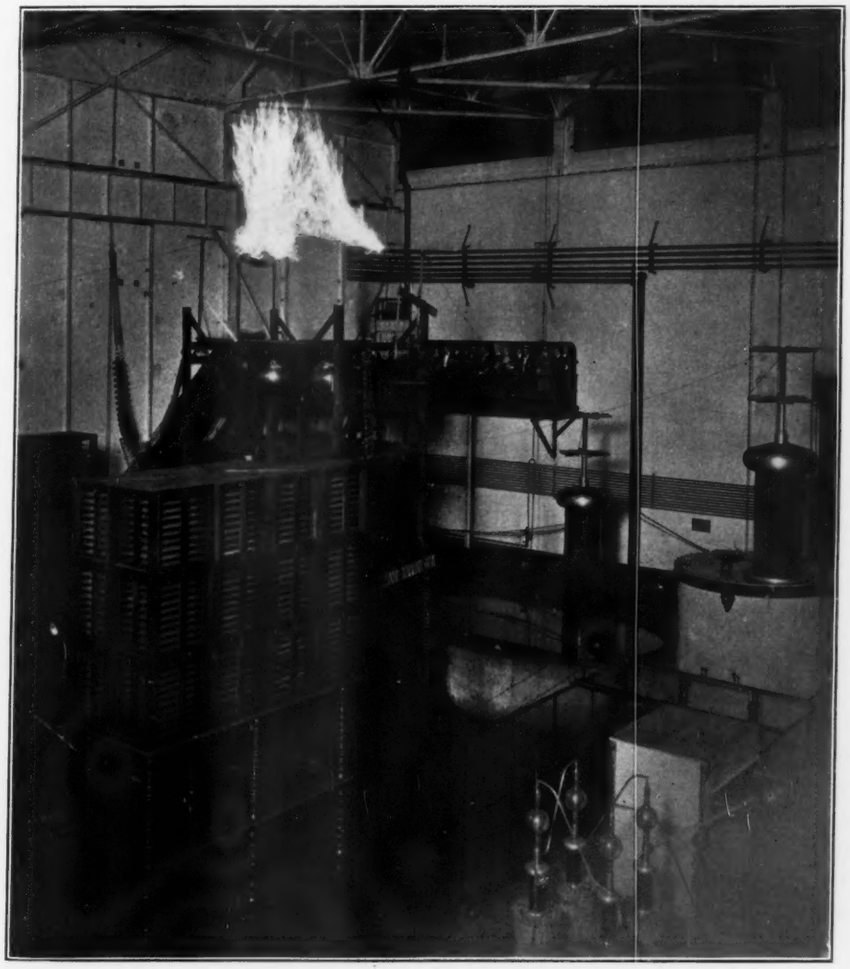
The strength of the insulation of lines operating at various voltages was determined by measurements with artificial lightning. By comparing the insulation strength with the maximum lightning voltage the ability to withstand lightning was determined.

The insulation of transmission lines is increased with the operating voltage. The higher the operating voltage the better able the insulation is to withstand lightning voltage.

(*Continued on page 258*)



A TWO MILLION VOLT MAN-MADE LIGHTNING STROKE
Miniature village used in research work to determine best methods of protection.



OBSERVING 1,000,000-VOLT, 3-PHASE 60-CYCLE TEST
Illustrating size of apparatus by comparison with people in background.

Marine Superheaters

A step towards greater economy in marine installations

By JOSEPH J. NELIS
Manager, Marine Department, Power Specialty Co., New York City

THE marine engineer has been the most conservative of any type of mechanical engineer, due principally to the conditions under which he operates. In marine work, the most important factor to be considered is reliability. The power plant is the life of the ship, and if anything goes wrong it is liable to disaster. If a ship should be in a storm near a rocky coast and the propelling equipment should fail, it would likely, and has in the past in a number of cases, caused the loss of the ship and the lives of the crew. All of this was particularly true before the days of wireless and is still to a great extent true in present day shipping.

Economy in fuel, while important, has always been subordinated to reliability. Any new devices in propelling equipment have necessarily been tried out on a moderate scale, and this is the reason for the slow growth in improved machinery aboard ship. Another reason for lack of greater economy is the untrained personnel. The marine engineer, as a rule, is a graduate from the fireroom, has little, if any, technical training and therefore is afraid to try out new and improved devices. Life aboard ship has not been attractive either from a standpoint of living or financial remuneration for the higher grade technical man, and the field has therefore been open to those who would follow this field, with the result that the sea-going engineer is a pronounced standpatter.

Steam pressures aboard ship in the merchant marine and, until recently, in the various navies, has been limited, due to the type of boiler used, namely the Scotch marine. A moderate increase in pressure or size of this type of boiler greatly increases its first cost, which has resulted in marine boilers practically all being operated at steam pressures of from 150 to 200 pounds. In merchant service and in the navies where water tube boilers are used principally on account of weight and space conditions, not on account of economy, the steam pressures average about 250 pounds.

The type of prime mover used has been mainly the reciprocating engine. In most of the larger ships this has been standardized in a triple expansion machine, as three cylinders can be best arranged for a steam pressure of about 200 pounds and a vacuum of 25 inches. Most of the reciprocating parts are made duplicate so that in case of trouble the engine can be compounded or even made simple, and the ship returned to port under its own power. Nearly all marine engineers were trained in the use of this type of engine and know how to operate it successfully.

For the first cost and the weight required, a superheater aboard ship will give the greatest financial return of any device that can be installed in a marine power plant. This fact has been known for a great number of years but, until ten years ago, superheaters were not standard practice aboard ship. In the early days, about 1870, a great deal of interest was taken in superheated steam, at which time Ericson, Isserwood and others conducted many experiments aboard ship with superheaters. In those days, the materials for the engine, piping and packing were not suited for high temperatures and the troubles caused by superheated steam prejudiced the operators against it and the use of superheat was abandoned except in isolated cases.

A few years before the World War the marine power plant had reached a state of standardization where no further improvements were possible with the Scotch boiler or the triple expansion engine and the more progressive marine engineers, particularly the Germans, again took up the use of superheat to reduce the high fuel cost aboard ships. Locomotive practice was followed, in which small bent tubes were placed inside the tubes of Scotch marine boilers, resulting in a very high superheat and a large pressure drop. This also required considerable oil in the engine cylinders and the oil caused trouble with the boilers. Superheat of 200° and over was easily obtained with this type of superheat, but the cost of the superheater, special valves, packing and piping, and the great care required in operation overcame the fuel economy, with the result that high superheat was again abandoned in marine work.

About fifteen years ago a number of the large marine interests in this country tried out a moderate degree

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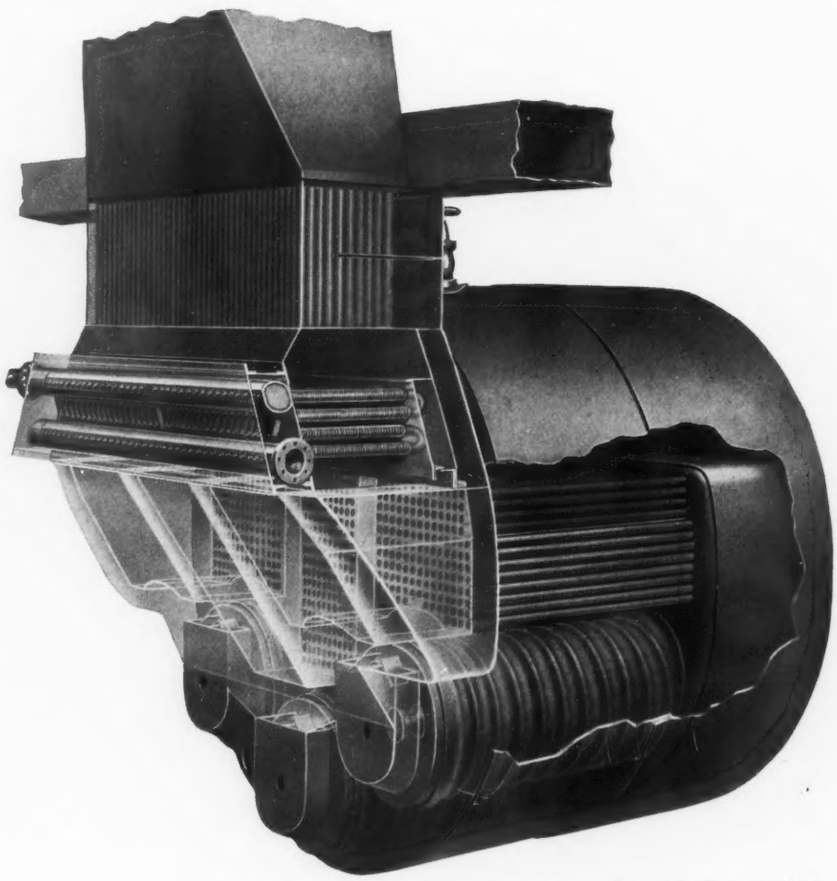


Courtesy The Power Specialty Co.

SCOTCH MARINE BOILER

Showing the waste heat type superheater and air heater tubes in the uptake. The superheater is above the boiler tubes.

Pioneering the Electric Locomotive

The development of the most important features of modern electric locomotives

By L. M. ASPINWALL
Railway Equipment Engineer, Westinghouse Electric and Manufacturing Co.

THE successful commercial production of any mechanical device is made in four distinct steps: the conception of the fundamental principle of operation; the evolution of a design to accomplish the desired result; the proving of the device by a prolonged period of operation, and the construction of the tools and fixtures for accurate quantity production.

The modern electric locomotive or car is an assembly of a considerable number of mechanical and electrical devices, each one of which has had to go through a long period of evolution before it was fitted to take its place as a component part of the structure. Only those who have closely followed the development of the electric locomotive, for the past thirty years or more, fully realize the vast amount of human effort which is bound up in its structure.

A modern main line electric locomotive will require about two thousand drawings for the production of the complete machine and its component parts. This statement alone gives some idea of the tremendous work back of this structure, but a better conception is obtained when we remember that these drawings represent only the final work completed after years of patient effort in working out innumerable details.

A list of the main problems which had to be met and solved includes the design of running gear, power brakes, propelling motors, auxiliary motors, control apparatus, collecting devices, indicating instruments, ventilating systems, sanding devices, steam heating systems, lightning protection and lighting systems. It has been necessary to explore practically every branch of physics in order to accomplish the desired results.

It is interesting to follow through these important problems and to observe how the tremendous resources of the Westinghouse Electric Company have been concentrated on them in the years that have passed and which were gradually solved, step by step. It is particularly gratifying to note that while time went on, although innumerable changes and improvements were made in design, it was seldom found necessary to change from the fundamental principle of design originally adopted.

Realizing that many problems would arise in the design of the mechanical parts of electric locomotives, the Westinghouse Company at an early date formed a co-operative arrangement with the Baldwin Locomotive Works and was thus enabled to make use of the fifty or more years of experience of this great organization in locomotive design and construction.

The first Baldwin-Westinghouse locomotive was completed in 1895, and was equipped with various experimental devices. The mechanical parts of the locomotive weighed 63,000 lbs., and the complete machine, with an equipment of four 150-h.p. motors, weighed 92,000 lbs. Direct-current, single-phase a-c. and three-phase a-c. motors were tested out on this locomotive. It is interesting to note that this original locomotive, with a direct-current equipment, is still doing good service on the Lackawanna & Wyoming Valley Railway.

Another interesting type of locomotive which was brought out by the Westinghouse Company in 1896 was one adopted for mine haulage. It was equipped with two 100-h.p. motors which were connected to two of three driving axles by means of double reduction gears. The middle set of drivers was of the "blind" type, and connecting rods were provided, connecting all wheels so that the total weight of the machine could be used for adhesion.

Referring to a descriptive catalogue of electric locomotives published by the Westinghouse Company and the Baldwin Locomotive Works in 1896, it is interesting to note that even at that early date these companies stood ready to supply locomotives up to 2,000-h.p. capacity, suitable for either freight or passenger service.

When the Westinghouse Company first entered the traction field, some thirty years ago, it was realized that the service required something in the way of a propelling motor, which must be far more sturdy than any electric motor so far designed.

A double-reduction, bi-polar motor, the No. 1, was the first produced, and it is interesting to note that even in this very early motor the general present-day method of mounting was practiced. One side of the motor was supported on the car axle by two bearings and the other side was spring supported.

The first motor was soon followed by a second motor design known as the No. 3, which was of the four-pole type, and which eliminated one pair of gears, making it the first successful single-reduction railway motor in existence. After a period of more than thirty years, some of these motors are still in operation.

This motor was followed, in 1894, by the design of the No. 12-A motor, which was probably the first totally enclosed motor used in railway service. With the completion of the design of this motor at this early date, the fundamental foundations were laid which are used in the large majority of the present-day railway motor designs, i.e., a motor supported on one side by axle bearings and on the other side by springs; a single-reduction gear drive; totally enclosed working parts; four-pole construction, and an armature built up from laminated toothed punchings.

It was early recognized by the Westinghouse Company that the key to extensive railway electrification of the future was through the use of the alternating-current system, and therefore, this company started development work accordingly, almost as soon as the direct-current motor was placed on an unquestionable commercial basis.

The first single-phase railway motors were built by the Westinghouse Company in 1894, and were placed in operation on an experimental line near the home of Mr. Westinghouse at Pittsburgh. These motors were rated at about 15 h.p. and were operated at low frequency. They represent the first steps taken respecting a method of development which eventually led to the present extensive equipments on the New York, New Haven & Hartford Railroad, the Pennsylvania Railroad, the Norfolk and Western Railway, and now the Virginian Railway.

In order to be able to increase the continuous capacity of motors to be applied to heavy duty locomotives in the space available, the Westinghouse Company, twenty years ago, practiced the method of forced ventilation for locomotive motors. This method has made it possible to materially increase motor ratings where large continuous capacity is required.

While the development of the railway motor and the locomotive was in progress, the development of control apparatus was not neglected, and a number of satisfactory hand controllers were brought out. It was soon recognized that the steadily increasing capacity of railway motors necessitated the development of a more

(*Continued on page 270*)

Rubber Pavement

A brief discussion of its advantages over wood, stone and asphalt as a paving material

By EDGAR S. DORR, '75
Consulting Engineer, Boston, Mass.

RUBBER pavement is a novelty in this country, but it is not in England, the first rubber pavement having been laid in London in 1870, and others in London and other English cities at intervals ever since.

The first impressions which would naturally occur to anyone upon hearing of such a pavement are that, while it would be noiseless, it would also be expensive, slippery when wet and short-lived, as it would be expected that steel tires and horse-shoe calks would quickly cut it up. Only two of these assumptions prove to be correct, it is noiseless and it is expensive, but it is not slippery even when wet, horses do not slip, neither do steel or rubber tires, automobiles do not skid or side-slip, and its endurance under all kinds of traffic is extraordinary.

To discuss the latter point first: rubber pavement is, and probably always will be, expensive, approximately three times the cost of other smooth pavements, such as wood and asphalt; in order to warrant its use it ought to last three times as long. This it will apparently easily do; the renewals made on parts of the pavement laid in London in 1870, after more than fifty years' use showed only 3-16 inch wear on the upper surface. (The singular fact was discovered that this pavement, which was in large slabs, had worn more on the under than on the upper surface, the explanation being that this material had moved or flowed slightly and then returned under the points of most intense pressure and had been abraded by the concrete base.) A trial patch in a western city showed ⅛ inch wear after 11 years' use, it was then taken up by the makers and relaid for further use around their factory: assuming that such a pavement would require renewal after it had worn down ½ inch, this pavement would have lasted 44 years. First cost should not be the governing consideration in selecting a pavement, the yearly cost should be, that is, the first cost divided by the number of years of life. The foregoing instances indicate that length of life will easily offset high first cost.

Rubber pavement has another property, that of almost completely suppressing the vibration due to rapidly moving traffic of all kinds. This property is peculiarly valuable in a pavement for iron bridges, even more particularly for the draw-spans. In the latter case the elasticity of a comparatively thin block enables it to accommodate itself to the unavoidable bending of the span when the draw is opened, so that altogether it is the best kind of pavement for draw-spans which has ever been brought forward. Suppression of vibration, often felt in office buildings from rapidly moving trucks, is also very desirable.

Rubber pavement has been made in two forms, slabs and blocks. The early rubber pavements in London were in the form of large slabs, unattached to the concrete base, but fastened at the curbs. This form seems to have been abandoned, probably on account of the wear on the under surface, and all the recent pavements have been made in the form of blocks, about the size of wooden blocks. Several forms have been tried, wooden blocks and concrete blocks have been capped with a half-inch layer of rubber; the difficulty has been to secure adhesion of the rubber to the body of the block. This was attempted in another case by vulcanizing the rubber cap to a steel plate which was attached to the concrete block by downward projecting lugs embedded in the concrete; the steel and rubber held together, but the block failed because of the cupping and detachment of the steel plate. The most successful English block has a body of a lean rubber composition, with just rubber enough in it to admit of vulcanizing the higher grade rubber cap to it. The sides of the block interlock by means of corrugations. Much of this kind has been laid in English cities, apparently with success. There is no apparent reason why it should not be laid on a *dry* cement-sand cushion, as wooden blocks are laid, as it is three inches thick, but in the paving around the Cenotaph, it was, as a matter of fact, laid on a *wet* mortar cushion, and failed badly, through crawling. The explanation given is that traffic was admitted too soon; this is doubtless correct, sufficient allowance was not made for the much longer time cement would take to set when covered with an impervious rubber mat.

In this country the lively interest in rubber pavement which many rubber companies have evinced in the last year or two has arisen from a business reason, the necessity for finding some profitable use for the vast quantities of rubber junk, now worthless, in the form of worn automobile tires. Rubber blocks are made of this junk, ground or macerated, and mixed with a portion of new rubber, vulcanized under 2,500 pounds pressure to the square inch and 400° F. heat. Here the effort has been to make a comparatively thin block, one or one and a half inches thick, and secure it in some way to the wooden deck of a bridge or the concrete base of a street. The principle of making a thin block is correct economically, for there is no need of a thick block of such slow wearing material.

Several forms have been developed in this country, and experimental patches of two kinds have been laid in Boston.

The first rubber pavement laid in Boston was on the Northern Avenue bridge, where traffic of all kinds is heavy enough to give it a good trial. It was laid last May, the blocks having been donated to the city by the makers, the Wright Brothers of Racine, Wisconsin. These blocks are 12x6x1 inch in thickness, with flaps about one-quarter inch thick extending horizontally from the base of the block on one side and one end, and fitting into recesses in the base of the adjoining blocks, so that the blocks fit with very close joints at the surface. These flaps are for the purpose of having screw-spikes driven through them into the wooden deck of a bridge. The deck is first painted with a liberal coat of rubber-asphalt cement, applied hot, the blocks are embedded in it and the joints filled with the same cement, and the screw-spikes driven. Up to date they show no signs of wear or injury, although they were accidentally subjected to a very severe test. The bridge carries a track of the Marginal Street Railway Company, and ordinary freight cars of the steam roads are hauled over it. One jumped the track and ran across the patch of rubber pavement shortly after it was laid. It might have been expected that the sharp flange of the car wheel would have cut through the one-inch rubber blocks; as a matter of fact, although it did cut grooves in the wooden planking on each side of the patch of rubber, the latter showed no signs of injury.

The patch, although not as long as would be desirable, about 14 feet in length, does show that the claims made for rubber pavement can be substantiated.

Another block has been developed by the Woven Hose Company, and a trial patch laid on Harrison Avenue at the entrance to the City Hospital. This block is 12x6x1½ inches thick and has, moulded onto its under surface, six protuberances or lugs, about the size and shape of black piano keys. This block is designed to be laid on

the concrete base of city streets, the lugs being embedded in a one-inch cushion of wet mortar and joints filled with hot asphalt. This is the first attempt to lay rubber pavement on a city street in Boston, or elsewhere in this country, to the writer's knowledge. It has not been laid long enough for conclusions to be drawn. This block cannot crawl; the trouble to be apprehended is the same as occurred in the English rubber-concrete block, failure of adhesion between the rubber and cement. There is also the possibility of water entering through an imperfectly cemented joint, collecting in cavities between the lugs (which it is difficult to avoid) and frost heaving the block. This experiment is very interesting; if the blocks remain in place through the winter it will demonstrate its fitness for use on city streets.

Another block developed in Boston is 36x18x1½ inches thick, a partial return to the slab idea; the intent being to minimize the cost of laying. This block has conical holes moulded in it to admit of the driving of screw-spikes into a wooden deck, the holes to be closed by conical rubber plugs cemented in. It has also another novel feature, a heavy wire mesh embedded close to the base, to prevent the crawling and abrading observed in the British slabs. This block is adapted to bridge paving, as is the Racine block; it has not had a trial as yet.

At the present writing the problem of rubber pavement is better solved here for bridges than for streets, unless the Woven Hose block proves a success. Either the Racine block or the slab-block last described is a practical block for bridges, and, while the writer has no cost data on the slab-block, the Racine block, at least, is more economical than a plank surface, on account of the frequent renewals required for the latter.

For street use the problem is a different one. Stability requires a thick block, economy in manufacture requires a thin one. The British rubber-composition block is as stable as a wood block, which requires no special fastening down. The thin block is more easily displaced and should be fastened down. But the British block is too expensive, it is said to cost $16 per square yard in England; if imported it would be subject to a 25 per cent tariff duty; the Racine block, according to the maker, may be furnished for $13 per square yard when made in quantity. Economy requires not only that the block should be thin, but also that, in its composition, as large a percentage of old rubber and as small a percentage of new rubber should be used as is practicable, because new rubber is the expensive ingredient. The Racine block contains 38 per cent of new rubber, the slab block 15-20 per cent, a considerable margin to be refined down.

CHICAGO BRIDGE PAVED WITH RUBBER BRICKS
This form of paving suppresses all vibration due to traffic.

Rubber pavement may be regarded as coming if not already arrived. The Racine block has made the most progress; many grade crossings in Wisconsin have been paved with it, in place of plank, which has to be renewed very frequently. Recently the Michigan Avenue bridge in Chicago has been paved with it throughout, including half-inch blocks on the sidewalks. It is reported to have given complete satisfaction. Rubber companies are actively experimenting; the Goodyear Company has developed a block and it is being used in and around Akron, Ohio, but the writer has no data in regard to it. Some think that the blocks which require spiking can be attached to a concrete base by driving spikes into the concrete while it is new, before the final set. This is possible but very difficult because the spiking would have to be done after the initial set and before the final set; it would be very difficult to manage the work so that it would be done at just the right age of the concrete, so that the cement would reset after being disturbed. So again the Woven Hose and similar blocks may be laid on bridges by being bedded in mastic instead of cement mortar.

Many problems are still to be worked out, but they will be solved, the cost will be lessened by quantity production as demand increases. The price of new rubber should decline as new rubber plantations come into bearing, while the supply of junk rubber promises to be interminable, and rubber pavement will make its appearance in American cities, first on bridges, then on streets, wherever its properties of noiselessness, non-slipperiness and absence of vibration are particularly desirable.

Gas and Fuel Engineering

A new graduate course to be offered by the Massachusetts Institute of Technology

By R. T. HASLAM AND J. T. WARD

Department of Chemical Engineering, Massachusetts Institute of Technology

THE development of means for the efficient production and use of heat and power has become one of the principal engineering problems of this generation. Coal, petroleum and water power comprise the three major sources from which we may expect to supply our constantly increasing requirements of energy.

The coal production of this country in 1922 was approximately 477,000,000 tons of an estimated value of $1,550,000,000 at the mine mouth and worth approximately $3,000,000,000 at the point of consumption. There was produced a further fuel supply of approximately 600,000,000 barrels of crude petroleum of which approximately 260,000,000 barrels was consumed as fuel oil in direct competition with coal. These fuels are used mainly for power production, generation of heat and chemical or metallurgical purposes. The present total power load of this country is difficult to estimate, but by far the greater part of it is steam generated.That this must of necessity be true is obvious from the fact that 93 per cent of the power load of the country is located east of the Rocky Mountains, whereas this area possesses only 30 per cent of the total potential water power, of which only a minor fraction has been developed.

It is obvious therefore that fuel is the primary source of energy. Unfortunately, however, the energy is seldom required at the mine mouth and consequently the coal and oil must be transported from the point of production to that of utilization. It has been estimated that one-third of the total freight handled by American railroads is coal, of which a large fraction is destined for consumption by the railroads themselves. The transportation cost is on the average approximately equal to that of the value of the raw coal.

The problem is therefore not only one of finding a suitable source of energy but also one of the transportation of that energy to the point where it is needed. The value of coal depends upon its content of potential chemical energy, readily released by the process of combustion. Fortunately the two major components of coal, carbon and hydrogen, possess exceedingly high energy content per unit weight so that the transportation of power in this form is as cheap and efficient as one can hope to realize if one restricts oneself to energy in chemical form. On the other hand, energy can be transported electrically as well as chemically and under the best present conditions an electron has an energy-transporting capacity approximately 140,000 times that of an atom of carbon. Furthermore, the frictional resistance to the movement of the electron is less than that involved in the transportation of the carbon, so that the overall efficiency of the electrical method of transportation of energy is much greater. Therefore, the overall efficiency of fuel utilization for power generation may be increased by further development of the electrical method of energy transportation. However, we already possess an intricate and exceedingly expensive equipment for carrying fuel to the consumer, but we largely lack the still more complicated and expensive installation necessary for the comprehensive energy transmission plan indicated above. Because of the enormous investment in the present system of power generation and distribution and also on account of the much greater amount of capital which would be required by the development of such a super-power plan its immediate realization is not possible.

The uses of coal for purposes other than power generation are extremely important. Very recent data are not available, but in 1915 approximately 50 per cent of the coal mined was consumed in industrial heating, for metallurgical purposes, gas manufacture and for similar uses. The capital invested in equipment in which coal is used for purposes other than power generation is enormous. The present capitalization of the gas industry alone is $5,000,000,000. It may be conservatively stated that a large part of this equipment is extremely wasteful of fuel and much of it has been designed to use specially selected coals. Notwithstanding the fact that our huge coal reserves may be regarded as almost untouched, it is certain that the exhaustion of the readily available supply of the fuels best adapted to a large number of our basic and most vital industries may be looked for before the end of the century. Our economic system precludes the possibility of conserving even the most valuable fuels by artificially restricting their use, and therefore *practical fuel conservation* becomes more *efficient fuel utilization*. The gas and fuel engineer is faced with a two-fold problem: first to increase the efficiency of existing methods and equipment and second to guide, as far as possible, future developments so that more effective means of utilizing heat and generating power may be secured.

An indication, at least, of the type of training which should be secured by men who expect to make gas and fuel engineering their professional work may be had from a very brief consideration of some of the more outstanding problems of fuel utilization.

The proportion of total coal mined and of petroleum produced to that which is used in the manufacture of artificial gas is small but the widespread use of this fuel for domestic purposes has so intensified its importance that the attention of engineers and scientific investigators is being attracted strongly to the problems of this public utility. Considerable improvement in the methods of gas production has been made in the last decade but unlike most modern industrial processes no radical changes in manufacturing methods have taken place. The technical problems of this industry are just beginning to receive intensive study from gas engineers and executives. Solutions to the many problems concerned with optimum operating conditions in different plants with various types of equipment and carbonizing coals of widely diverse properties have only been begun. As is the case in the power field the necessity of using low grade coals is already making its influence felt. The manufacture of water gas is an important part of most city gas plants, but it is certain that the maximum possible efficiency of this process has by no means been reached.

The gas industry is at present so organized that city gas is generally distributed at low pressures by plants located close to the point of use. High pressure gas distribution has not yet been sufficiently developed to enable this industry to plan its manufacture and distribution on the highly centralized plan toward which electrically transmitted power is surely tending. However, those executives in the gas industry immediately concerned with increasing the sales of gas undoubtedly look to high pressure distribution as a possible means of increasing the use of gas for house heating and for industrial purposes. Certain commercial aspects, such as properly devised rates, are extremely important in this industry, and the development of the engineering phases of gas manufacture are certain to be distinctly influenced by the peculiar economic considerations involved. The gas engineer must possess at least a working knowledge of these commercial conditions and must appreciate thoroughly

their influence on future engineering progress in gas manufacture and use.

Technical advances in general fuel utilization are becoming increasingly apparent. The progress of boiler furnace design is a case in point. In coal fired steam generating equipment, wasteful and expensive hand firing has been largely superseded by less costly and more efficient stoker firing. The constant striving for higher boiler efficiencies is now causing the stoker to give way to powdered coal in many of the large central generating stations. Moreover, designers are now well aware that the highest overall efficiencies demand that the design of the heat absorbing surface must be adapted to a setting wherein optimum combustion conditions may be secured.

One of the most important uses of coal is for the production of metallurgical coke. The general tendency toward more uniform output in the steel industry is making possible the replacement of the beehive oven by the more economical by-product type. The many unsolved problems in this field are complicated by the certainty that even with all other possible variables fixed, the quality of the raw material supply—coal—is sure to decrease.

In 1922, approximately 11.5 per cent of the coal mined was anthracite, the principal use of which is for domestic heating. The cost of this fuel in the consumer's cellar is about three times its value at the mine. The price of domestic anthracite is almost certain to increase and the production of substitutes is now being attempted. The widespread and constantly increasing market for domestic fuel is certain to focus attention on the necessity for the development of cheaper substitutes for anthracite and for more efficient house heating equipment.

The field of industrial furnace design and regulation is very clearly within the province of the fuel engineer. Progress toward more efficient furnaces is apparent in the case of some types of metallurgical units, but it is the exception rather than the rule to see industrial furnaces either designed or operated in accordance with even present day information on the principles of combustion. Our knowledge of the composition of American coals is very meager and yet these data might have an important influence in the general study of coal combustion and carbonization problems. The United States is far behind the European countries in this respect. The relatively high cost and poor quality of British coal when used in domestic heating has been an effective urge to research. The work on carbonization of British coals done by the British Fuels Research Board and by some of the larger English gas companies is far in advance of the investigations carried on in this country.

Major advances in the engineering phases of industrial development are the result of painstaking, systematic research or of fortuitous observation and industry has learned not to depend upon the latter method for consistent advance. In most cases the solution of industrial fuel utilization problems has been assigned to power engineers or to some one with no particular experience on fuels. The history of many plants is replete with examples of incorrectly designed furnaces. The present high-capacity boiler settings have in many cases been achieved only through the experience gained by much and expensive empirically planned construction. Industry, however, is now beginning to appreciate that it has specific use for the engineer who possesses expert knowledge of fuel utilization, coupled with sympathetic appreciation of the major engineering aspects of the industry and of the necessary economic policy involved. The well trained fuel engineer must have not only adequate technical equipment but also breadth of vision to solve in an adequate manner the present and future fuel problems.

Incompletely organized training in gas and fuel engineering has been obtainable in various technical schools for some time, and research work on fuels of great value has been carried on in isolated instances. Only of late, however, has the proper kind of training for a man who intends to devote his entire energies to fuel utilization, received from educators the attention which it has merited. The more complete organization of such training of engineers is at this time a consistent and logical extension of the Institute's activities.

The primary purpose of the Institute is often stated to be the affording to students that combination of general, scientific, and professional training which will fit them to take leading positions in the fields of engineering and scientific investigation. These four-year professional courses are fundamental in character and broad in scope. Research in pure and applied science of such value as to be widely recognized and highly valued is carried on constantly in the Institute laboratories.

At first glance it would not seem illogical to organize a course in gas and fuel engineering along the conventional undergraduate lines. A little reflection, however, on the wide scope of the industries wherein a fuel engineer would function strongly indicates that training for expert work in a highly specialized field can be based only on a broad engineering foundation. It has therefore been decided that the proper training of gas and fuel engineers can be carried out most effectively at the Institute by graduate work. Since the professional work of both gas and fuel engineers is concerned with the same fundamental phenomena it is clear that graduate training in these branches of engineering must include much of the same basic subject matter. It must not be forgotten that for some years the Institute has offered training in certain phases of these branches of engineering, but the prime importance of this field has indicated the desirability of a more formal organization for the most effective work. Therefore, to this end, a graduate course in gas and fuel engineering will be offered beginning October, 1925.

The work in gas and fuel engineering will consist of an academic year devoted exclusively to classroom work and lectures, which will be followed by six months' experimental work in industrial plants. At the outset the experimental work will be carried out at two field stations—one probably located in Buffalo and another located in or about Boston.

The Master's Degree in gas and fuel engineering will be awarded on completion of this part of the course. Since the ultimate solution of many of the problems in these fields will depend on thorough knowledge of the basic phenomena and underlying reactions, the prosecution of intensive research is an important function of this work. Students of promise will therefore be encouraged to remain at the Institute for further study and research work leading to the Doctor's Degree.

It is intended to organize the field work on the general plan of the School for Chemical Engineering Practice, which has proved to be so satisfactory. The importance of the specific type of field work which is a part of these courses can hardly be overestimated. In most cases the engineer's real experience with industrial practice is secured by his actual work in industry after graduation. This method is inefficient because the industry cannot generally afford the man the opportunity for diversified work which would have the greatest educational value. Moreover it is quite impracticable to give gas and fuel engineers a satisfactory training by means of small scale laboratory ex-

(*Continued on page 260*)

RECENT BOOKS

Introduction to Organic Research. E. Emmet Reid, Professor of Organic Chemistry, Johns Hopkins University. 343 p. D. Van Nostrand Co., New York, 1924. Price $4.50.

"The world is beginning to realize that its material progress depends on research. Research as a vocation or even as an avocation offers alluring joys to the individual as well as to the race. This book is put forward with the hope of assisting those beginning research and of aiding some not now engaged in it to take it up." Though the volume is the direct product of an eminent organic chemist, yet not a few distinguished contemporaries in other fields have made specially prepared contributions and the serious student of any branch of chemistry or chemical engineering will find that the limitation implied by the title is not a serious one.

The first portion of the volume deals with the necessary qualities of the researcher, the various classes, opportunities and limitations of investigators, the incentives and rewards of the searcher, and particularly with the problems to be examined: their choice, the methods of attack and the sources of time and strength for their pursuit.

Since the first duty of the research worker is to learn all that may be already known in his particular problem the second portion of the book deals with the records of existing knowledge and how they may be found. The study of the chemical journals and other publications, the use of the library, the recording of the information found therein, the discussion of patent searching, are all of vital importance and live interest and each reader will willingly spend a profitable hour with these chapters.

The final sections of the book deal more particularly with the study of known organic compounds, with the factors involved in the comparative study of various methods of preparation of a given substance, with the needful considerations for the synthesis of new compounds, and with the general study of structure, reactions, and organic analysis. All these chapters are copiously illustrated with so many interesting examples from actual experience that the book is laid down with reluctance.

Special mention should be made of the chapter on Plant Processes by Dr. C. M. Stine, Chemical Director of the Du Pont Company, whose discussion of the commercial requirements of successful chemical processes should be ever in the mind of the laboratory research worker.

The volume is unique in its field and should be thoughtfully examined by every research student who would do his best work with least effort.

E. H. HUNTRESS, '20.

Marine Plankton. A Handbook for Students and Amateur Workers. By James Johnstone, Andrew Scott, and H. C. Chadwick. University Press of Liverpool, 1924.—194 p. illus.

By the word "plankton" is meant the sum total of organisms which float upon or near the surface of a body of water, as distinguished from the animals which swim actively about, or the plants which are attached to the bottom. The plankton consists of animals and plants and of some organisms which exhibit the characteristics of both kingdoms, which are mostly microscopic. For those who may be situated near the ocean, or lake, and enjoy observations with a microscope, the plankton forms a never-ending source of interest and joy. More than this, it has a very great scientific and economic importance, because the plankton forms the fundamental food supply for marine fishes. The study of the plankton, therefore, is one of the fundamental sciences connected with the investigation of fisheries. It enables one to study the distribution of marine fishes, and possibly to predict their relative abundance in various localities at different times of the year, and in different years.

One of the most important centers for this branch of study has been the Biological Laboratory at Port Erin, Isle of Man, in the Irish Sea. There, under the direction of the late Sir William Herdman of the University of Liverpool, important investigations have been carried on for a number of years. The results described in this volume are largely based upon those investigations.

The book is beautifully illustrated by simple but adequate illustrations of these fascinating organisms, many of which are very surprising. One would scarcely recognize the baby barnacles shown on Plate XVI, and the baby crabs on Plate XVII, which are almost equally different from their parents. Plate III shows many kinds of diatoms, which in their chemical and physiological relations to marine animals, correspond to the grass of the fields for land animals.

This book describes the various forms of life which are included in the plankton in such a way that this may be recognized by the amateur as well as by the professional zoölogist, and then describes the distribution of these forms. This chapter is followed by one on the chemistry of the plankton and the synthesis of organic matter in the sea.

There is an appendix which describes methods of collecting and preserving these organisms. It is a book which everyone who visits the seashore and has access to a microscope should have with him.

R. P. BIGELOW.

Charles Proteus Steinmetz: a Biography. By John W. Hammond. New York: Century Co., 1924. 489 p.

The year 1924 has witnessed the addition to electrical literature of two outstanding biographical publications—an autobiography entitled "From Immigrant to Inventor," by Dr. M. I. Pupin, Professor of Electromechanics at Columbia University, and this biography of Dr. Steinmetz by J. W. Hammond.

Many had hoped for an autobiography from Dr. Steinmetz's own pen, but that idea did not appeal to him and he compromised by selecting Mr. Hammond as his biographer and aiding him in much of the work. The resulting volume details the life of the "electrical wizard" from his childhood in Breslau, through his socialistic student days and subsequent coming to America, to his establishment in his laboratory at the General Electric Company in Schenectady.

MONTHLY NEWS

Noise-Reducing Rail Expansion Joint. A new type of rail expansion joint is in use in Toronto which, after a year of use, shows no deterioration of surrounding pavement through pounding, and hardly perceptible sound when cars are operated over them at a fair rate of speed.

The principal feature claimed for this joint is that a floored centre section raised the flange of the wheel so that the tread is lifted off the head of the rail at the moment of passing over the gap, thus doing away with pounding.

The maximum movement allowed for at each joint between the temperatures of 120 degrees above and 20 degees below zero is 3 3-16 ins.

The parts, assembly and operation of the Kinnear joint is described as follows: The expansion joint is made up of three integral parts, A, B and C, as shown in the illustration.

A and C each consist of short pieces of T. T. C. standard 122 lb. rail cut to the shape shown. B is made up of a short piece of 150 lb. rail, which is similar to the T.T.C. standard 122 lb. rail but having a guard, and a floor depth of ½ in. against 1 7-16 in. floor of the groove in the standard rail. There are, in addition, a base plate and two guide splice bars. These pieces are welded together, forming a single unit.

Assembly

In the illustration C is shown in position, while A has been represented withdrawn from its guides, namely the base plate and guide splice bars of unit B. The features of the joint may be appreciated referring to relation between C and B:

(a) On head of joint at I and II can be seen the splice fashioned joint, which provides that if the wheel tread were to take a bearing upon the rail there is no actual opening to jump.

(b) At III is shown the flooring of the groove.

(c) At IV note riser from the groove depth of standard rail to the floored portion. This rise is very gradual, being 1-32 in. to 1 in., and provides against jarring when flange of wheel approaches or leaves the flooring.—*Electric Traction.*

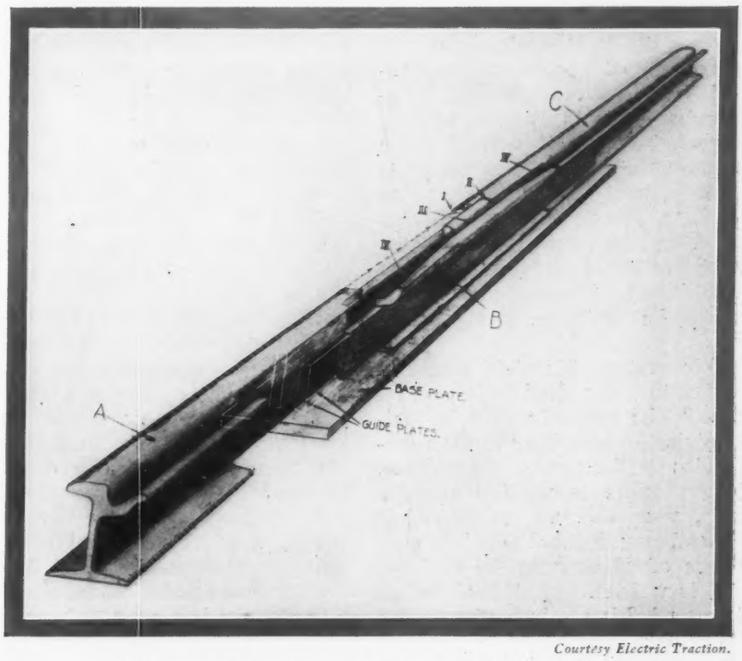
Two More American Airships. Admiral Moffet, Chief of the Bureau of Naval Aeronautics, has stated that the Navy now has worked out complete plans for a 6,000,000 cu. ft. airship—exceeding in all respects the 5,000,000 cu. ft. English airships being built which are more than twice the size of our Los Angeles.

The new ship will have a length of 785 feet, diameter 122 ft., speed 70 nautical miles per hour, maximum horsepower 3,900, endurance at maximum speed 65.5 hours or 4,590 nautical miles, and will use helium gas.

The Goodyear Zeppelin Corporation —which includes among its organization E. A. Lehman, formerly of the Zeppelin Co., at Friedrichshafen, Dr. Carl Arnstein, Chief Engineer of the Zeppelin Co., and Dr. Hugo Eckener, head of the Zeppelin plant—has started working plans for a 6,000,000 cu. ft. airship.—*Aviation.*

Development of Mercury Turbine. There is now under construction for the Hartford (Conn.) Electric Light Co. an improved mercury boiler of the sectionalized type, designed for operation at 70 lbs. per sq. in. This will drive a mercury turbine of the three-stage type and the boiler should be ready for shipment in December. It is anticipated that there will be an increase of about 12 per cent in the amount utilized of the energy of the mercury vapor over the previous installation. Running such equipment on a base load, it is expected that one kilowatt-hour can be developed on about 10,000 B.T.U., compared with about 15,500 B.T.U. in the best large steam generating stations.

The new boiler for Hartford will be made up in six units with tubes three inches in diameter. These tubes will be provided with cores, and they can be removed for cleaning, if necessary, by chiseling off the header weld. The tubes will have tapered ends to receive radiant heat from the fire and will be about five feet long. The rating of the improved unit for Hartford will be about 4,200 k.w., of which 1,800 k.w. will be in the mercury turbine-driven generator and the rest in steam.—*Power.*



Courtesy Electric Traction.

NOISE-REDUCING RAIL EXPANSION JOINT

Wheel tread is raised from rail head at joint, preventing pounding.

EDITORIALS

COMMUNICATION FROM PROF. FABRY

Editor, "Tech Engineering News"—

Dear Sir:

The October, 1924, number of "Tech Engineering News" contains an editorial on the metric system, and I beg permission to present the following remarks suggested by that excellent article.

The author says that the metric system "made no change in the units used in measuring time or angles." In regard to angles, this statement seems incorrect. The metric system contains a decimal system for the measurement of angles. Its employment is very convenient and is increasingly in use in France. Indeed, it is probable that it will at some not distant date entirely replace the old sexagesimal division of angles in France. The passage, quoted above from the editorial, indicates that the deciminal division of angles is unfamiliar in America, and it may, therefore, be desirable to explain it here.

In this system, the right angle is divided into a hundred parts called "grades." The grade in turn is decimally divisible, according to the regular rules (decigrade, centigrade, etc.). An angle is written—not in degrees, minutes, and seconds—but as an ordinary decimal number, e.g., an angle of 43 degrees, 37 feet, 40 inches, is written 48^G .4753. The advantages of this method of notation are considerable.

1st. Its writing and printing are much simpler and are less subject to errors than in the sexagesimal system.

2nd. All calculations with angles are simplified: for instance, the addition or subtraction of angles, or again the multiplication or division, which are complicated in the sexagesimal system, become as simple as ordinary operations on decimal numbers. If the reader has any doubt on this subject, I would recommend him to make the following little experiment:

Write down, at random, a dozen angles in the sexagesimal system as degrees, minutes and seconds. Then ask any fellow-student to express the halves of these angles. Note the time necessary for this operation, and count the number of mistakes made. Then do the same thing with these angles written in the decimal system. Compare the time employed at arriving at the half angle, and the number of errors made. You can likewise make a similar comparison for the addition or subtraction of such angles.

3rd. In the calculation of the values of the trigonometrical functions by means of tables, the decimal system presents great advantages. First of all, the trigonometrical tables are very simple. There is a great simplification for angles exceeding 90 degrees, since the latter is replaced by the simple number 100 and not by the awkward number 90. The supplement or the complement of an angle is obtained with the greatest ease.

For example, the sine of the obtuse angle 148^G .5142 is obtained in taking the cos 48^G .5142 which is the same as the former angle dropping the figure 1.

4th. The very nearly exact relation between the length of the meter and the terrestrial quadrant, gives a valuable property to the lengths of the meridian arcs: one grade on the terrestrial meridian is almost exactly 100 kilometers, and one centigrade is one kilometer.

It is thus easy to realize the advantages of the decimal system of angular measurements, but these advantages are not confined to theory. The system has proved its value in practice during many years. It is exclusively employed in the French "Service Géographique" (Geodetic Survey) not only for computations, but also for all survey operations. The divided circles employed in this service are universally divided into grades and decimal fractions of the same. The reading of these circles by means of verniers or by microscopes is swifter, and less subject to error, than with sexagesimal circles. The trigonometric tables needed have long been published. Their clarity, ease of reading, and interpolation, leave nothing to be desired. All the charts published by the French Geographical Service carry meridians and parallels of latitude in the decimal system.

Outside the government service, most of the private surveys employ the decimal system for the measurement of angles in their charts and plans. For the last fifteen years, it has been decided that both systems should be taught in the schools, and that in the examinations, the students should have a choice between them. As a matter of fact, nearly all choose the decimal system, knowing that their work is thereby rendered easier, and the chance of making mistakes is diminished.

As far as concerns the decimal division of the inch recently proposed in the U. S. Senate, it may be said that the proposition shows that the advantage of decimal subdivision begins to be recognized. However, the adoption of this plan would be a national and international calamity. The reasons which have kept England and the United States from adopting the metric system are evident: *i.e.*, the inconvenience of making the change, and the appreciable expense in countries which are highly industrialized. The adoption of the system proposed in the Senate would, however, entail the same difficulties, without having all the advantages of a perfectly co-ordinated system, correlated not only with measures of length, but also with weight, surfaces and volumes. The metric system co-ordinates with the electrical units, whose employment is universal, and is already employed by scientists all over the world, as well as by the men of affairs of almost the whole European continent.

As a Frenchman, I am naturally proud of hearing the metric system described as the "French system." It must, however, be recognized that this title is no longer correct. It was created in France, but is a gift to the world. This gift no longer belongs to France. Since its beginning, France has associated all the nations who have been willing to unite with her. She has suppressed her own national units of measure in the hope of creating a truly international system. This hope has been realized in a large measure. It is not only in France that the metric system is largely employed. It is employed in Germany, Switzerland, Italy, Spain, and in short, in all civi-

(*Continued on page 262*)

—and even electrical engineers are needed in the electrical industry

Nowadays the electrical industry needs so many types of men that it may be well to point out it still needs engineers, good engineers—but with a difference.

Vision, initiative, technical skill are needed qualities, now as always. But here's another. Can you work on the team? Will you be able to back up the other members in the manufacturing and commercial ends of the business?

The engineer today should be no recluse in a laboratory. He can make his work more effective once he sees how it relates to the work of men around him.

In your studies and college activities, you have the chance now to develop this point of view. In the broader activities of the electrical industry, you may have the chance later on to carry it further.

Published in the interest of Electrical Development by an Institution that will be helped by whatever helps the Industry.

Western Electric Company

Since 1869 makers and distributors of electrical equipment

Number 45 of a series

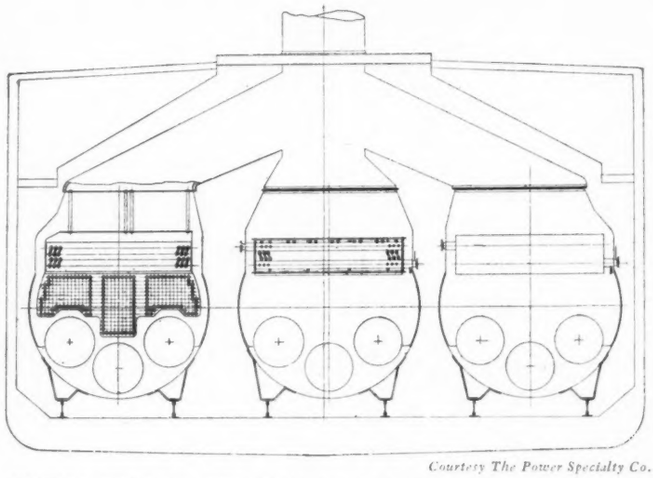
Marine Superheaters

(*Continued from page 248*)

of superheat, using waste gas temperature from the Scotch boilers. This has proved satisfactory and is standard in American ships. This type of superheater has also been put into a great number of foreign ships flying British, Norwegian, French, Dutch and Japanese flags. It meets the requirements of foolproofness, reliability and ruggedness required in marine work.

The waste heat type superheater has made a very attractive fuel saving, due to the fact that no additional fuel is burned or required to obtain the superheat and the heat obtained from the gases is dissipated in the high pressure cylinder up to the point of cut-off, which is usually from ⅜ to ½ stroke. A moderate superheat of 50° will about supply sufficient heat to overcome the initial condensation in the high pressure cylinder of a triple engine up to the point of cut-off. During the rest of the stroke, when the steam is expanding it becomes sufficiently moist to give the amount of lubrication required and allows the marine engineer to operate his main engine without using oil in the cylinder, which is standard practice in saturated steam marine work. A great number of ships are now fitted with waste heat type superheaters in which all of the auxiliaries also operate at this moderately superheated steam, and the fuel savings obtained by using superheated steam in auxiliaries, while only a small amount as compared to the total steam, are a much larger percentage owing to the high steam rates of the usual wasteful marine auxiliary such as reciprocating pumps, etc.

The use of a moderate superheat of about 50° does not require any changes in the valves or piping or in the type of packing used for joints, piston rods, etc., and this is an important factor, particularly in old ships, where changes of this kind would be expensive.



Courtesy The Power Specialty Co.

SECTION THROUGH FIRE-ROOM OF A VESSEL SHOWING LOCATION OF WASTE HEAT TYPE SUPERHEATERS

Another factor of importance in waste heat type superheaters is the steadiness of the heat obtained. The temperature of the gases leaving the boiler does not vary greatly and as the boilers operate with a fixed load condition, the quantity of the steam passing through the superheaters is also quite constant, and this makes for a very steady steam temperature.

When the marine power plant becomes modernized and a higher grade of technical man takes charge, it is probable that water tube boilers for high pressures with economizers for lower stack temperatures and radiant heat or other types of superheaters for much higher steam temperatures will be used in the boiler room. The engine room will allow the use of this higher pressure and temperature without oil getting back to the boilers, but until this condition obtains, it will be necessary for the present day marine engineer to operate at a moderate superheat which is reliable and gives a satisfactory reduction in fuel consumption.

The waste heat superheater is now installed in approximately 400 ships and is standard practice in America and rapidly becoming so in several other foreign countries. High temperature superheaters are occasionally installed but have invariably given trouble and have then been removed as they did not meet the most important feature of marine operation, namely, reliability.

When one considers the requirements of marine service, it will readily be seen why a moderate superheat has proven reliable and satisfactory in marine service.

Lightning

(*Continued from page 247*)

The exact voltage where danger from lightning disappears varies with conditions but in general there will probably be little trouble on 220 KV lines. Special precautions must be taken, however, to cause the lightning voltages to divide evenly over the apparatus.

Where Lightning Strikes and Chance of Being Struck

Researches in the laboratory show that lightning from a cloud over head does not always strike the highest object or rod unless the height of that object is over two and five-tenths per cent of the cloud height. The division of hits is about equal between cloud and ground when the rod is one and one-tenth per cent of the cloud height. The chance of being hit is less when the cloud is not directly overhead. Lightning either strikes the rod or some distance away. There is a protected area around the rod with a radius equal to four times the height of the rod where no ground hits occur.

These researches show that a man standing directly under the storm center would be hit fifteen times out of a hundred strokes, while a man flat on the ground would be struck about once in one hundred strokes. A 25-foot building would be struck every time. The chance of a thunder cloud of sufficient voltage to cause a discharge being over any particular object is small. The chance of any particular object being struck is thus generally very small indeed.

The lightning rod seems to be of real value for the protection of buildings. Except for buildings in exposed positions or in special cases, as magazines, the cost of a rod unless it is quite low, is not warranted from the standpoint of the cost of insurance.

Under certain conditions lightning may cause sparks within metal tanks.

PERHAPS WE CAN HELP YOU

In the many years devoted to the study of blasting problems, we have developed a series of explosives, one or more of which is adapted to most conditions found in this country, and we are constantly making changes, improvements, and additions to meet new conditions.

Moreover, in making this study, our men have acquired a broad knowledge of blasting, which is at the service of the industries which depend upon our products. A combination of this experience, with the operator's detailed knowledge of his own work, often results in valuable improvements in blasting practice.

We do not offer this co-operation with the idea that it is anything remarkable, or that it is sure to reduce costs; but we ask those to accept our offer who think they may profit by it.

To the student we offer another service. The following authoritative books on blasting and explosives are his for the asking:

Scientific Quarry Blasting, Hercoblasting, Modern Road Building, Safety in the Use of Explosives, Eliminating Waste in Blasting, Shot Firing by Electricity, Hercules Galvanometers & Rheostats, Dynamite: the New Aladdin's Lamp, Conquering the Earth. Please write for the ones that interest you. Address, Hercules Powder Co., 941 King Street, Wilmington, Del.

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WILKES-BARRE, PA.
WILMINGTON, DEL.

Gas and Fuel

(*Continued from page 253*)

periments, because no matter how extensive the laboratory equipment may be, the conditions particularly when dealing with high temperatures, are necessarily different from those which usually exist in practical work.

At the field stations the men will study the actual working of the plant under Institute professors and will carry out quantitative tests on processes and equipment to determine the mechanism of operation and how their efficiency may be increased. Similarly to the work in the School of Chemical Engineering Practice, this type of field work possesses three outstanding advantages:

1. The men devote their entire time to intensive educational work and receive no compensation from the industry.
2. The theoretical instruction precedes the field work and therefore the emphasis is on the application of the theory to practice.
3. In order that intensive and individual instruction may be given, only small groups of students will be handled.

The preparation required of students taking gas and fuel engineering will be substantially that of graduates of Courses II, VI, VIII and X and similar courses at the Institute or at other recognized schools.

Some of the more important graduate subjects which will form a part of this course are: Gas Engineering, Primary Fuels, Secondary Fuels, Combustion of Fuels, Furnace and Retort Design, Development and Use of Power, Power Plant Design and Equipment, Refractories, Materials of Construction, Economic Geology of Fuels, Economics of the Gas Industry and Rate Making, Distribution of Manufactured Gas, Internal Combustion Engines and Gas Appliances.

Progress is surely beginning to be effected in more efficient fuel utilization but a much greater rate of advancement must be made possible. The wide diversity of industry wherein the gas and fuel engineer will function has been briefly reviewed in order to emphasize the extent of the training required for successful accomplishment in this field. The more outstanding problems of fuel utilization certainly demonstrate that this branch of engineering is fertile in opportunities for effective technical progress. The specific economic problems involved in many phases of gas and fuel manufacture and use indicate the necessity for broad vision and for sympathetic appreciation of the non-technical factors involved. It is believed that the necessity for making the training of gas and fuel engineers intensively specialized and based on a good general engineering education has been demonstrated. This course has been planned on these basic principles and with the firm belief that a very important part in future industrial advancement is certain to be played by the thoroughly trained gas and fuel engineer.

Coolie Labor Versus the Steam Shovel. At the inception of the Sutlej Valley irrigation project in the Punjab, British India, some two years ago, exhaustive investigations were made of the relative costs of coolie labor and machinery for the excavating portion of the work. The rising price of the former and the uncertainty of its supply caused the engineers to decide in favor of machine excavating equipment.

It is interesting to note that two years' experience has justified their decision to the extent of nearly halving the costs that would have been required for this section of the work had coolie labor been employed; not a small item when it is considered that the volume of excavation will equal that of the Panama Canal.

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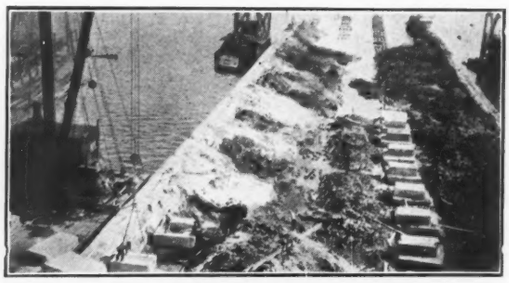

Bay State Lighters laying Granite Piers for Revere Sugar Refinery plant in Mystic River at Charlestown—filling is being deposited back of completed sea walls on the outer end while pier foundations of granite masonry are being constructed.

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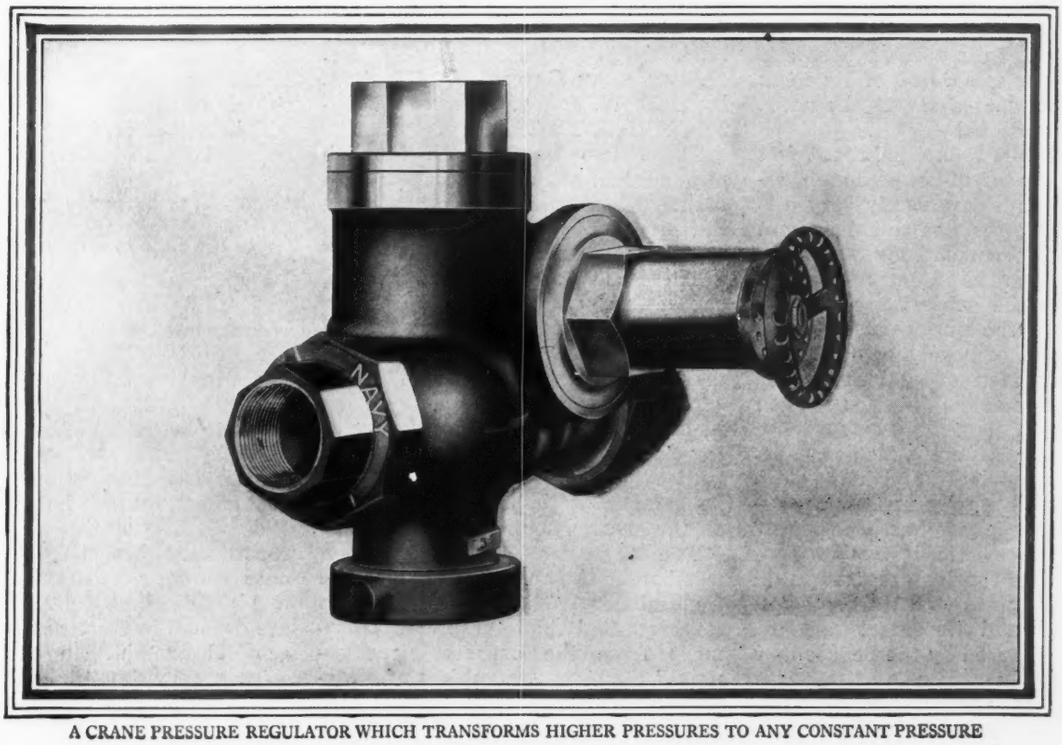

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Communication

(*Continued from page 256*)

lized countries of continental Europe. It has, little by little, made a conquest of a large part of the whole world by the sole force of its logic and simplicity. It deserves the name of the international system.

To conclude, I should point out that the questions of units, although apparently simple, are really very difficult. It is impossible to solve these questions by considering them exclusively from the scientific point of view. With the subject are inevitably mingled the questions of habit, of commerce, of psychology, and unfortunately even of national pride. The condition of the question in each country is a perpetual compromise between these different factors, especially between logic and habit. One must proceed slowly and with caution. Half a century has been necessary for the metric system to have supplanted in continental Europe all the preceding national unit systems. Any hasty and imperfect decision like that proposed by the Senate may well become disastrous.

Very truly yours,

CHARLES FABRY,
Faculty of Science,
University of Paris.

Recent Books

(*Continued from page 255*)

The Electrolytic Rectifier. By N. A. de Bruyne. London: Pitman, 1924. 75 p.

Alternating Current Rectification. By L. B. W. Jolley. London: Chapman & Hall, 1924. 352 p.

These two books from English presses deal with a subject of constantly increasing importance in the superpower developments of the modern electrical era.

The little volume by de Bruyne, one of the Pitman Technical Primer Series, discusses the special type of rectifier—the electrolytic—in a clear and concise manner, giving references for farther study. The author in his preface apologizes "for writing such a small book on so big a subject," but offers as excuse that he believes it to be "the first book on the electrolytic rectifier."

The larger work by Mr. Jolley, a member of the research staff of the General Electric Co. Ltd., offers "a mathematical and practical treatment from the engineering viewpoint" of the entire subject of alternating current rectification, and treats all phases of the subject in a scholarly manner. Mechanical rectifiers, mercury vapor rectifiers, vacuum tubes, tungar rectifiers, the photo-electric cell rectifier—all types are included. The chapters are followed by tabulated bibliographies, valuable not only for the references which they offer, but for their excellence of bibliographic form.

METALLURGY

Practical Microscopical Metallography. By R. H. Greaves and H. Wrighton. London: Chapman & Hall, 1924. 125 p.

Having in mind the needs both of students of metallurgy and of students of engineering who study metallography as a part of their engineering course, the authors have considered the structures of industrial metals and alloys "in the light of their constitution but with special reference to their mechanical properties and practical utility." Two chapters are devoted to the technique of microscopical examination and of photomicrography, but the greater part of the book describes the structures and properties of iron, steel, copper and various alloys, with over 100 typical photomicrographs.

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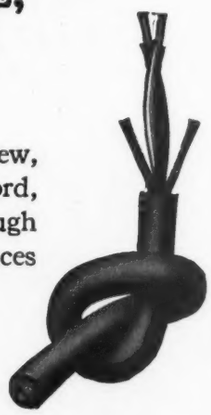

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Mercury Vapor

(*Continued from page 245*)

mined by the temperatures of the reactions taking place. This feature of the design is taken care of by the exact location of the chambers "A" and "B" in the correct relation to give the desired characteristics of operation.

The tank "B" is a bubbler and simply serves the purpose of preventing the pressure in the system from exceeding a certain amount, in this case three inches. It consists essentially of a small closed tank, into which a branch from the header is led. This pipe extends into the tank until it is under a three-inch seal of liquid mercury. A standpipe in the bubbler at the correct level discharges excess mercury from the bubbler into the return line. If the pressure in the line exceeds three inches the bubbler operates. The vapor bubbles through the seal and passes through the discharge pipe at the top into the condenser "F," figure (1), where the vapor is condensed and returned to the boiler.

The condenser is merely a system of return bends, each downcomer of which is enclosed in a larger pipe through which water is circulated, thus cooling and condensing the vapors passing into it.

The mercury boiler just described has certain limitations as to vertical height and mercury in the vaporizing gap. The height of the mercury film in the space between the two shells should not exceed thirty inches. The reason for this is that the density of mercury is so great that if the vertical height of mercury is excessive a pressure will be created at the bottom of the boiler, so that proper circulation could not take place under ordinary conditions. The result would be that the bottom of the boiler would develop a temperature considerably higher than the top. Such a condition is not desirable and impairs the efficiency of the boiler.

The particular design of the boiler used was determined by the fact that electrical heat was to be applied by induction. This has been found to be the most satisfactory method of heating for the type of installation shown.

Laminated coils were used, because in the event of a blowout a coil could be quickly and easily put back into service by removing and replacing a lamination. On account of the high temperature generated it was necessary to insulate the coils from the heat of the boiler; this is a protective measure to prevent the burning up of the coil wrappings and ultimately a short circuit in the coil. Two inches of magnesia, or refractory brick, surrounded the generator. An air gap of one inch was then allowed, then the coils, the laminations of which were four inches wide.

Cool air was applied to the air gap between the coils and boiler, being drawn through by the use of an inductive draft fan connected to the top of a sheet metal casing which surrounded the boiler outside of the coils. This casing was so designed and built as to allow air to enter and pass through the air gap from the bottom, being drawn off at the top. This method of cooling was fairly satisfactory, but had to be watched carefully so as to be sure that each boiler was getting proper circulation. In the actual installation made there were sometimes three boilers in operation, but only one cooling fan was available.

The amount of mercury required by a system such as has been described can only be determined by experiment. Actual calculations are valuable only in determining the approximate quantity of mercury required. Small globules of condensate lodge in any pocket or depression in the lines, which causes an apparent loss of mercury. This feature makes the accurate laying out of the system necessary.

Oxidation also removes a quantity of mercury. The formation of oxide makes it necessary to clean out the entire system occasionally with an air blast, recovering as much of the oxide as possible.

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Spavinaw Water Supply Project

(*Continued from page 243*)

excavated ahead of laying only a short distance and immediately backfilled. A trench unit usually consisted of two gasoline shovels excavating, a locomotive or caterpillar crane laying, and a dragline backfilling. When operations were at their height, there were five such units working simultaneously along the line. Thirty-five to forty joints of pipe was considered a good day's work for one unit. The center of gravity of each length of pipe was marked on it in the yards, so that when a cable was slipped around the joint at this point, it swung perfectly level over into the ditch. The cranes were each equipped with their own track in two lengths, which they carried along with them, or with crawler tractors, and so left the railroad track free for the passing pipe trains.

In general, the conduit trench followed the contours without deep cuts or fills. The typical trench section called for 18-inch cover, 84 inches wide for the 60-inch pipe, and 78 inches for the 54-inch. Unless the trench was wet or in rock, the pipe was laid on the natural material; in the two cases excepted, suitable material was supplied for the bed. After joining the lengths the pipe was backfilled. Caulking was done from the inside after the backfilling was finished and any slight settlement had taken place. At a later date space between pipes was filled with mortar to make a perfectly smooth interior. Any curve up to 3° was handled by deflections in the flexible joint, but at sharper curves or sudden changes of grade, monolithic concrete jackets, reinforced for the proper stresses, were constructed around the ends of two abutting lengths.

There were many special laying problems, solved in various ways. At narrow ravines, the pipe was carried across on reinforced concrete beams and piers. Under the five railroads crossed, the pipe was entirely surrounded by precast, reinforced concrete pipe of 84-inch diameter and the space between filled with hydraulically packed sand. In the upper section of the conduit was the heavy rock excavation known as Haddon's Cut, a limestone ledge a mile long, through which a 22-foot trench was opened. Portable compressors furnished the air for drilling with jack-hammers. The first ten feet was taken out with gas shovels, and the remainder with a clam-shell bucket. For about a half-mile east of the tunnel approach there was some very heavy excavation through soft, shaly formation. A trench averaging 25 feet in depth was dug. A dragline stripped the first ten feet of cover to a 40-foot width, and after this was done, gasoline shovels on pads excavated the remainder of the trench to the usual width. Due to the extra width of the trench at the top, no cave-ins were experienced.

Verdigris River, with its high, narrow banks offered a problem. Here an inverted siphon 700 feet long was excavated through the rock 35 feet beneath the bed of the river, and the pipe lowered into this on tracks on which a pipe cradle fitted. Pipe, cradle and track were all grouted solidly into this tunnel.

Grand River, at the upper end of the conduit, is 800 feet wide at the crossing with rock outcroppings in the bed of the stream. Here cofferdams were constructed, eight in number, the railroad bridge piers serving as

(*Continued on page 268*)

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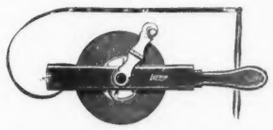

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Those looking forward to careers in business often associate the big accomplishments with men in private offices, who sit back of massive desks. As a matter of fact, there are many important men in an organization like Westinghouse who seldom use a desk or office at all. They achieve by *going to other men's* offices. They are termed "*sales* engineers".

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Authorities declared it was impractical; laws were urged against it; yet the salesman, Westinghouse, threw back of alternating current, the strength of his selling personality—with results that can be witnessed in every branch of industrial life today.

Following the example of its Founder, the Westinghouse organization includes a body of engineers whose work is to carry electrical advancement into every nook and corner of the world. They have sold electrification to the factories, the farms, the homes, the railroads, the mines, the ships. They are mechanical and electrical, engineers whose imaginations are fired, not merely by engineering achievement, but by the benefits from such achievement to "the market".

Engineering needs men of sales ability and sales personality; and industry needs to have them in engineering. Organizations like Westinghouse, must *sell* before they can *serve.*

Westinghouse

ACHIEVEMENT & OPPORTUNITY

W
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Spavinaw Project

(*Continued from page 266*)

one side of the cofferdams. A trench was excavated in the rock, the pipe laid from the bridge, and the entire line encased in a concrete jacket. An unusually wet season, with floods that came regularly with the construction of each cofferdam, made this a long and tedious job. The bridge was so constructed that the 30-foot steel spans, ten in number, in the center of the stream, could be taken out. Flood reports were sent down the valley daily, and at news of one approaching locomotive cranes lifted these spans out and carried them to the bank and the flood carried its debris on through the bridge. This was done seven times in the course of the work. When the last length of pipe was laid on the banks of this river, the conduit was completed and ready for the gates to be lifted at the dam. On November 1, 1924, the water roared into the line at the dam and the second day thereafter arrived at Mohawk, before a delighted and happy group of citizens who had planned and worked for this consummation.

For years Tulsa had been using the turbid, oily, hard, salty waters of the Arkansas River. It had built an expensive and up-to-date filter plant which could remedy many of the deficiences of this water but which could not make it palatable or could not soften it without prohibitive expense. There could be no industrial development for a city with such a bad supply. Now Tulsa has a soft, palatable water in unlimited quantity, and is proud to say that it has put through a big project and has secured one of the best water supplies in the country.

Aluminate Cement. Aluminate cement, which has been used in France for twelve years, is just beginning to be manufactured in this country. Its high cost is due to an appreciable per cent of aluminum ore, but it is extremely valuable for some kinds of work since it acts like ordinary cement until it sets, when it acquires as much strength in 24 hours as any other cement acquires in 28 days.—*Cement and Engineering News.*

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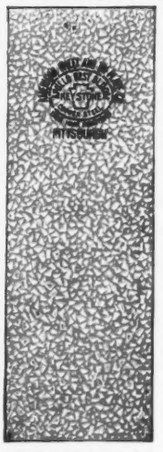

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THE DISADVANTAGE OF POOR LIGHTING.

As thousands of our industrial plants are operating to-day with poor lighting and in some cases with extremely bad facilities, it would seem that the importance of the subject of lighting has not been given the serious consideration by those responsible for such conditions.

Poor lighting is one of the most serious handicaps under which a manufacturing establishment can operate. First of all, poor lighting is the cause of a large number of accidents in industrial plants; and it is singular that accident reports do not yet properly classify the hazards of poor lighting, which in many cases is the primary cause of an accident attributed to what is really a secondary cause. Safety engineers and other officials who make accident reports should always consider the condition of the lighting when working up a report of accident causes, for it plays an important part in a great many casualties and is apt to be overlooked. All accidents due to poor lighting are accidents of neglect, and are preventable. The poor lighting accident hazard is clearly chargeable to management and not men. It is a difficult matter to make such progress with Safety First in a plant which has neglected to provide one of the fundamental requirements of accident prevention—good lighting.

Probably no one single factor connected with the equipment of a plant so directly affects the efficiency and inefficiency as the quality and quantity of the lighting. The curtailment of production of all working under the disadvantage of poor lighting represents a big loss each day; the poorer the lighting the less able is the working force to function efficiently. Quality and quantity both suffer, representing a preventable loss wholly removable by improving the lighting.

Under poor lighting condition, we cannot expect and rarely do we find an orderly, clean factory. Darkened places encourage careless habits and workers are often led to deposit discarded articles or material which should be deposited elsewhere. The eyesight of those who attempt to use their eyes continually in insufficient light, below nature's demands, is often affected. Too much light, such as is furnished by bright, unprotected lights, is as harmful as too little illumination; both are fundamentally wrong. Nature's own illuminant, daylight, is unequalled for our requirements of lighting.

The eye is best suited to daylight in the proper quantity. Sun glare should be avoided, and in the darkened hours proper artificial illumination provided. Daylight should be utilized to the fullest extent. It is supplied free in abundant quantity for our use. Modern invention has supplied a means whereby the interior of buildings can be lighted by daylight, and all the advantages secured which is furnished by good lighting at the smallest cost.

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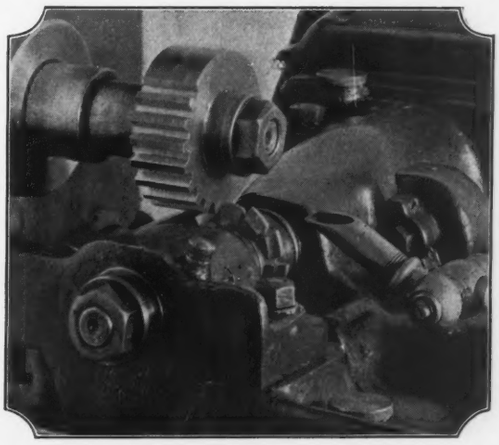

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BROWN & SHARPE MFG. CO.
PROVIDENCE, R. I., U.S.A.

Electric Locomotive

(*Continued from page 249*)

sturdy form of control than the ordinary hand type and that some form of power should be applied which would enable the control to be operated from a distant point.

A careful consideration of sources available for the operation of the control led to the adoption of compressed air, and the twenty-eight years which have passed since this decision was made have shown with ever-increasing force the wisdom of this choice.

The first electro-pneumatic control equipment consisted of a drum type of controller with a pneumatic operating head, which employed four cylinders. One cylinder was used to move the controller "on," notch by notch, by means of a pawl and ratchet wheel; another cylinder, acting through a rack and pinion, was used to throw it "off." The other two cylinders were used to operate the drum reverser through a rack and pinion. These operating devices proved remarkably durable and are still in service after a duty of more than twenty years.

The next step in the electro-pneumatic control development was splitting up of the control into individual switches, each operated by means of its own pneumatic cylinder. These switches were at first arranged in a circular group, but later in a straight line. Since the first Westinghouse control equipments of this type were constructed, many improvements have been made in the structural details, but the separate control switch unit, operated by compressed air and controlled by an electro-magnet, is still accepted as the best form of control for heavy railway work.

The development of locomotives with an ever-increasing capacity of motors and control necessitated a corresponding development in devices capable of collecting heavy currents, and in this field the energies of Westinghouse kept pace with the necessity.

Various forms of collecting devices were developed which could be used with third-rail installations. Notable among these devices was an electro-pneumatically operated third rail shoe, which was arranged so that it could be thrown into position for making contact with the third rail by merely pressing a button. When not in use, and when the locomotive was collecting current from an overhead line, the shoe folded up out of the way of road obstructions when a second button was pressed. This type of third rail collector has been in use on the New York, New Haven and Hartford Railroad for more than seventeen years.

Continued patient effort finally produced an air-operated pantograph with sliding collectors which was capable of collecting the heavy currents used in main-line service and which would hold to the overhead wire at high speed. This type of collector, a distinct Westinghouse product, is today the accepted and best practical device for this purpose.

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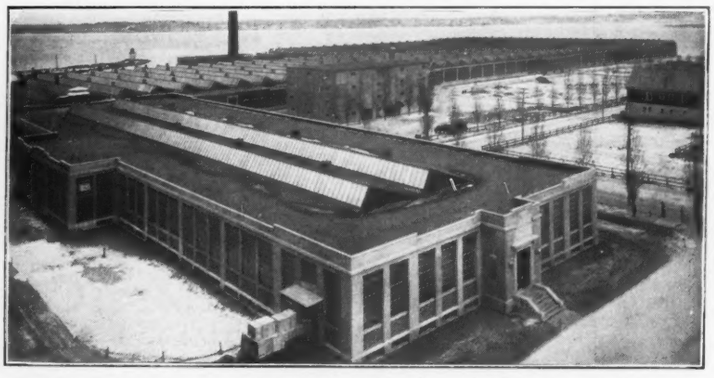

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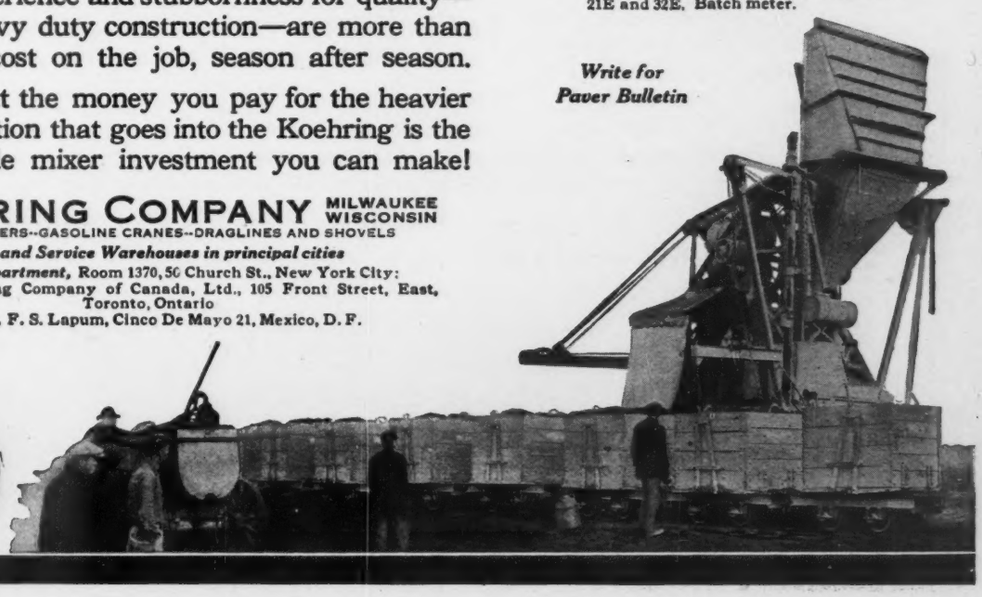

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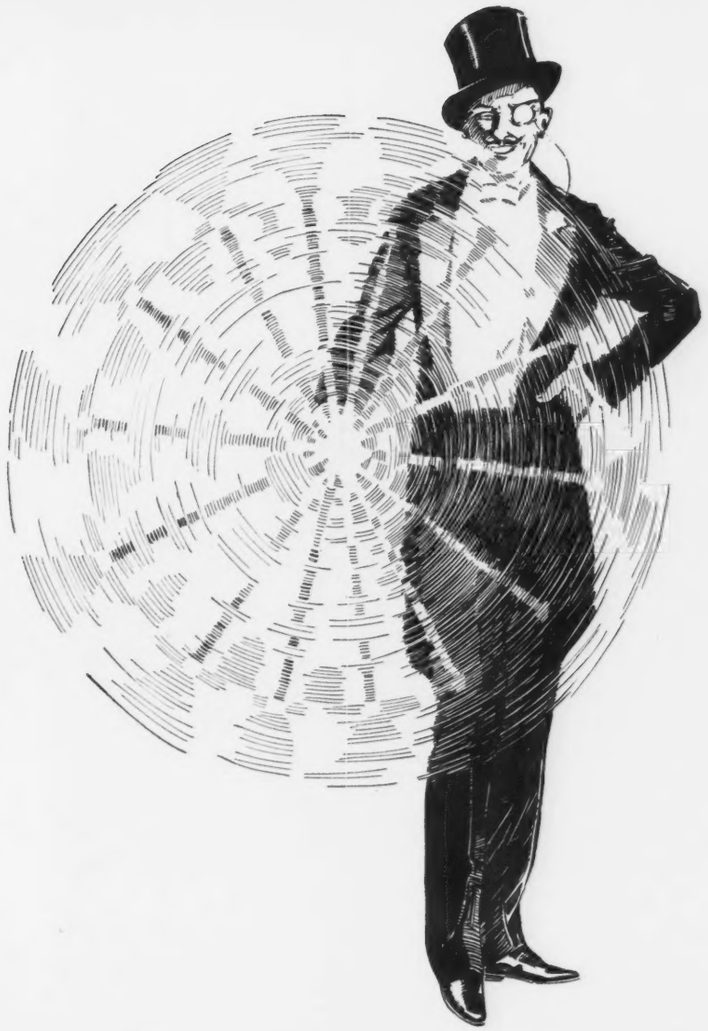

What Is Timken Dual Duty?

YOU know how it is; trying to make your finger keep up with a twirling cane. The cane may twirl all right, but it keeps trying to run out ahead of your finger—and off.

That is, the cane has at least two motions. It spins *around*, and also moves *along* your finger.

This same tendency toward motion in more than one direction exists in connection with nearly everything that revolves. The hubs of your automobile, for example, not only have the familiar spinning force applied, but there is also the sidewise push of turning corners or running on a crowned road. The transmission gears, too, not only turn 'round and 'round, but the mountings are pushed upon from the end by the same pressure felt in the clutch pedal.

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That's Timken Dual Duty, made possible only by the Timken Taper principle. When Timkens are engineered into automobiles, farm machinery and industrial appliances, it is accepted that the bearings are equal to the whole job of caring for *both* radial and thrust loads without compromise or complication.

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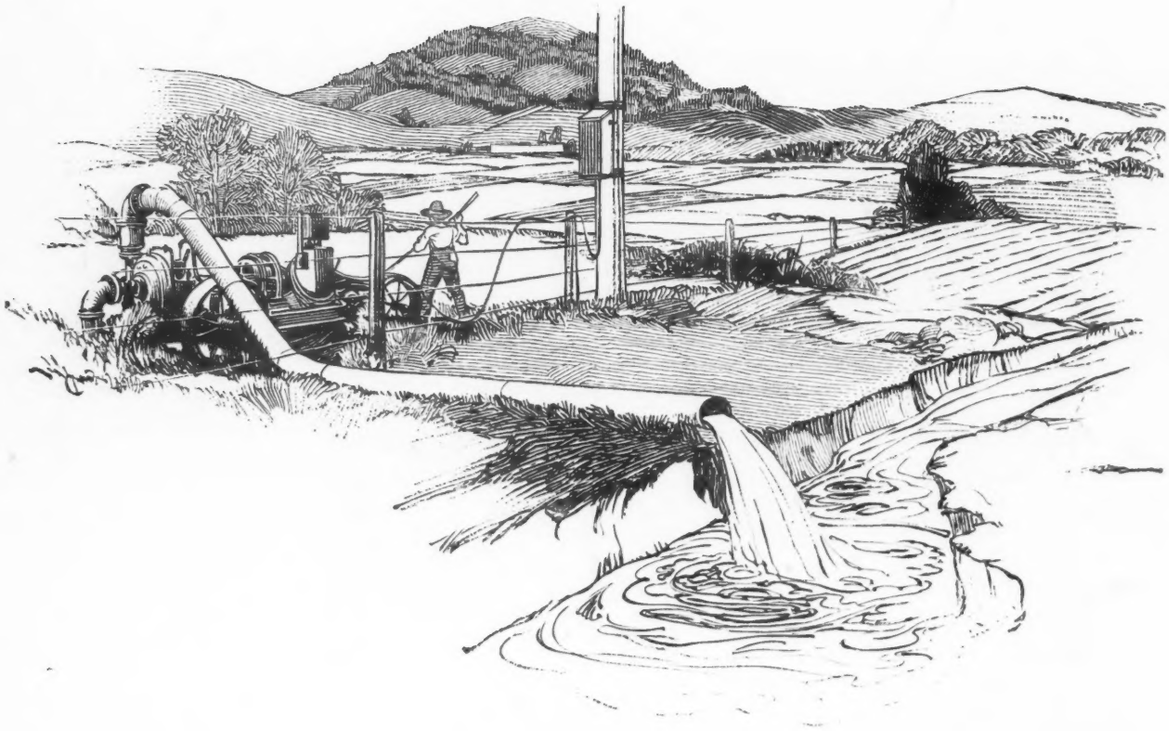

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